PROPOSAL OF THREE-YEAR PROGRAM OF TRAINING AND RESEARCH IN URBAN TRANSPORTATION

UNIVERSITY OF *Minnesota*

CENTER FOR URBAN AND REGIONAL AFFAIRS · MINNEAPOLIS, MINNESOTA 55455

January 14, 1969

Asst. Secretary for Metropolitan Development
Dept. of Housing and Urban Development (HUD)
Washington, D.C. 20410

and

Administrator
Urban Mass Transportation Administration
Department of Transportation (DOT)
Washington, D.C. 20590

Dear Sirs:

Enclosed is a proposal for a training and research grant under Section 11 of the Urban Mass Transportation Act of 1964.

The University of Minnesota is situated in the business center of a five-state area. Over the years, members of the faculty of the University of Minnesota have built up close working relationships with the business community and with all levels of local government. These relationships have been enhanced by the proximity of the state capitol.

Within this five-state area there is at present no university providing a strong program of training and research in urban transportation. However, at the University of Minnesota, faculty members in a variety of disciplines have developed strong interest in urban transportation and have cooperated on an ad hoc basis. We feel that a strong interdisciplinary program can result by providing coordination through the Center for Urban and Regional Affairs. It would then be possible to provide a program by which students could be trained in various aspects of urban transportation.

The current proposal would provide the funding to start such a coordinating activity, would provide fellowship funds to attract students to the program, and would provide certain research activities. (The research projects described herein are typical of the research which we believe should be undertaken both to support the instruction and to develop facilities for use by local agencies.)

Should you wish further information on any of the technical aspects of this proposal, please feel free to contact me or Professor D. L. Gerlough.

Very truly yours,

John R. Borchert

John R. Borchert
Director

JRB/ska

Enclosure

Proposal of

THREE-YEAR PROGRAM OF TRAINING AND RESEARCH

in

URBAN TRANSPORTATION

submitted to

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

and

U.S. DEPARTMENT OF TRANSPORTATION

by

The University of Minnesota

January 15, 1969

LEGAL NAME:

Regents of the University of Minnesota

AUTHORIZED REPRESENTATIVE:

John R. Borchert, Director
Center for Urban & Regional Affairs

Alternate: Daniel L. Gerlough
Professor of Transportation Engineering and
Urban Transportation Coordinator
Center for Urban and Regional Affairs

STATEMENT OF LEGAL AUTHORITY:

UNIVERSITY OF MINNESOTA

BOARD OF REGENTS

MINUTES

EXTRACT

June 11, 1960

RESOLVED, That the Vice President, Business Administration, or the Assistant Vice President, Business Administration, be and they each are empowered, on behalf of the Regents of the University of Minnesota, to execute all contracts, agreements, and all other instruments with the government of the United States or its agencies or subdivisions.

* * * * * *

I, S. B. Garrison, hereby certify that I am Assistant Secretary of the Board of Regents of the University of Minnesota, Minneapolis, Minnesota, and that the foregoing is a true and correct copy of the resolution adopted by the vote of a majority of the members of the Board of Regents of the University of Minnesota present at a meeting on June 11, 1960, at which a quorum was present.

Date January 22, 1969

S. B. Garrison

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I. INTRODUCTION

The University of Minnesota proposes to establish a Program in Urban Transportation under the aegis of the Center for Urban and Regional Affairs (CURA). To facilitate the establishment of such a program, the University seeks financial support in the form of a grant under Section 11 of the Urban Mass Transportation Act of 1964.

Because of its location within a major urban complex, center of regional business and finance, and seat of state government, the University of Minnesota has a long history of close and fruitful relationships between faculty, students and community. Consequently, use of the urban laboratory has developed intensively yet quite naturally over a long period in the Minnesota faculty. An important part of this development has been concerned with transportation. The University has recently moved to fill important gaps and strengthen its offerings in urban transportation. Meanwhile, faculty from diverse centers of action in this field have joined to form a coordinated training program and to submit this proposal.

The program will be broadly interdisciplinary, with participation by many University departments and by several local governmental agencies. The program will constitute training in the broadest sense and will consist of an instructional program supported by a research program; there will be, in addition, provision for internships in appropriate agencies.

The objectives of the proposed program include:

1. Bringing together of those faculty members now actively concerned with various aspects of urban transportation to form a synergism.

2. Provision of a medium whereby faculty members not now active in the field of urban transportation but who have an interest in the field, will be able to make contributions to the field.

3. Provision of a medium whereby the faculty and members of local governmental agencies can interact to improve urban transportation.

4. Provision of a medium for the sponsorship of interdisciplinary research.

5. Transmission to students a body of knowledge which will enable them to make important contributions to the field of urban transportation.

This faculty group seeks support mainly to implement four elements of the program.

1. Student fellowships.

2. A core seminar.

3. Certain new courses.

4. Research projects integral to the training program.

II. MANAGEMENT OF PROPOSED PROGRAM

Rationale

The proposed program will be operated within the Center for Urban and Regional Affairs. Authority over Program policy will be vested in an interdisciplinary Administrative Committee. The Administrative Committee will be assisted by a Faculty Advisory Panel and an Agency Advisory Panel.

This structure is clearly more loose than a new department or an especially prescribed curriculum which would lead to a degree in "Urban Transportation." The faculty involved here has made the choice deliberately out of several considerations.

Urban areas in general and urban transportation in particular are very complex systems. Organizations which plan and develop components of these systems are becoming increasingly multi-disciplinary. It is becoming clear that the work of these organizations demands not so often a new type of generalist but more commonly a team with both knowledge of a variety of techniques or systems and a focus on a common problem.

In response to this situation, faculty and students of several disciplines have sought to collaborate and to involve as much as possible the University's relevant talent and manpower. The goals of the program are to emphasize flexibility and to encourage individual student initiative and innovation, and to produce the widest possible interaction among faculty rather than create a structure which tends to "define out of the field" some potential contributors.

There is a long and rich tradition of inter-departmental cooperation of the kind at Minnesota. Hence it was natural that the Center for Urban and Regional Affairs should be established to facilitate and expand program coordination efforts in the urban field.

The following paragraphs discuss the various aspects of the management organization.

Center for Urban and Regional Affairs

The Center for Urban and Regional Affairs was recently established by the Board of Regents to coordinate and facilitate urban and regional research, training and service within the University. The Center for Urban and Regional Affairs is administratively directly responsible to the Office of the Vice-President for Academic Administration. The Center is directed by Professor John R. Borchert, who has carried out and directed urban transportation research and has served as a consultant to various public transportation agencies. The Center has two offices: an Office of Research and an Office of Community Programs, which report to the director of the Center. Under these two offices, numerous new urban programs have been developed at the University. Both the Office of Research and the Office of Community Programs are staffed by faculty members, each of whom holds a joint appointment in a line department and in the Center for Urban and Regional Affairs.

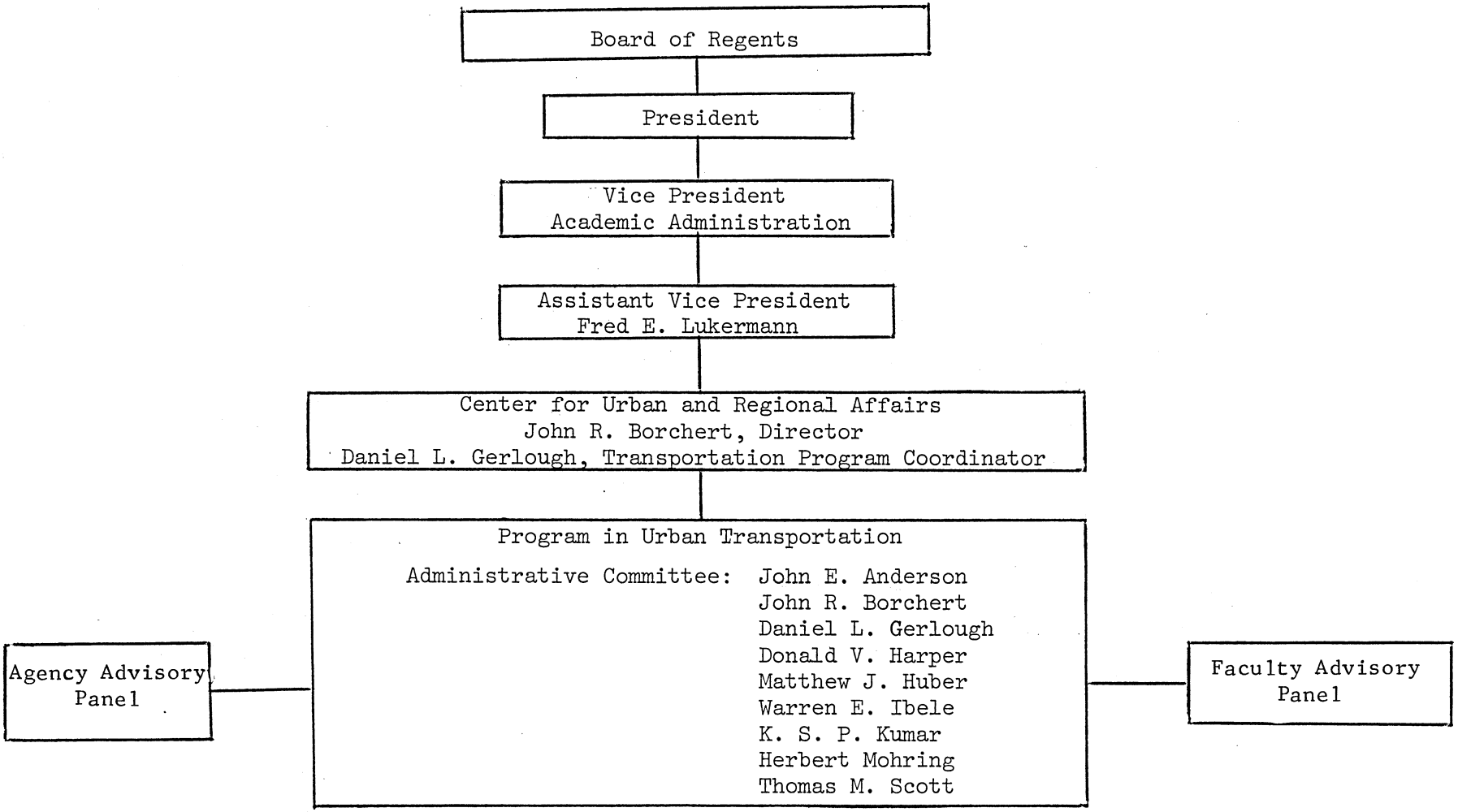
To facilitate the development and management of the proposed University of Minnesota Urban Transportation Training and Research Program, Daniel L. Gerlough, Professor of Transportation Engineering, has assumed a joint appointment with the Center's Office of Research. His primary duties as a coordinator within the Center will be to work with the proposed urban transportation training and research program. Both Professor Gerlough and Professor Borchert will sit on the Administrative Committee, which will manage the Program in Urban Transportation.

The following chart graphically presents the organizational framework of the proposed Program.(see Page II - 3)

Administrative Committee

The Administrative Committee will be charged with the overall administration of the Program in Urban Transportation. Its duties will include selection of recipients of fellowships, recommendation of suitable research projects, the sponsoring of seminars and short courses, and such other duties as may be appropriate.

ORGANIZATIONAL FRAMEWORK



The initial appointments to the Administrative Committee include the people who are initiating the program.

Chairman and Program Coordinator:
Daniel L. Gerlough, Professor of Transportation Engineering

John E. Anderson, Associate Professor of Mechanical Engineering

John R. Borchert, Professor of Geography and Director of the Center for Urban and Regional Affairs

Donald V. Harper, Professor and Chairman of the Management, Production and Transportation Department

Matthew J. Huber, Associate Professor of Civil Engineering

Warren E. Ibele, Professor of Mechanical Engineering and Associate Dean of the Graduate School

K. S. P. Kumar, Associate Professor of Electrical Engineering

Herbert Mohring, Professor of Economics

Thomas M. Scott, Associate Professor of Political Science.

Biographic sketches of these men are included in Appendix A of this proposal.

Faculty Advisory Panel

The Faculty Panel will provide advice to the Administrative Committee covering all aspects of the program. In addition, the Panel will constitute a pool from which advisors to students may be drawn. Membership on the panel will be quite broad and will include but not be limited to faculty members from the following schools and departments:

Aeronautical Engineering
Architecture
Business Administration
Civil Engineering
Economics
Electrical Engineering
Geology and Geophysics
Geography
Law
Mechanical Engineering
Political Science
Psychology
Public Administration (School of Public Affairs)
Public Health
Sociology

Agency Advisory Panel

The Agency Advisory Panel will assist the Administrative Committee by providing advice on needs for new courses (both regular curriculum and short courses), needs for research, sources of internships and other appropriate matters.

Membership of the Agency Advisory Panel will include the following agencies at the outset:

Public Bodies: Metropolitan Council
*Minnesota Highway Department
State Planning Agency
*Twin Cities Metropolitan Transit Commission

Private Industry: *Control Data Corporation
*Rosemount Engineering Company

*Letters of intent to participate in this Program in Urban Transportation have already been received from starred agencies, and copies of these letters are included in Appendix C.

Graduate School

As with all other graduate students, the Graduate School will maintain the official records of academic progress of students enrolled in the proposed program. As with other fellowships, the fiscal administration of fellowship funds will be performed by the Graduate School.

Research Contracts and Grants Section

Fiscal administration of research funds under the proposed program will be carried out by the Research Contracts and Grants Section of the Business Office.

III. TRAINING PROGRAM

General Outline

The training program proposed will include courses which undergraduate students will be encouraged to take, and specialized degree programs will be provided for graduate students. Training fellowships will be provided for three levels of graduate student:

A. Recent recipients of the bachelor's degree

B. Holders of the master's degree

C. Persons engaged in professional practice of a field related to urban transportation who wish to return to the University for graduate study to broaden their viewpoints and to learn new techniques that will assist them in their profession.

Each graduate student will select a discipline relevant to urban transportation, such selection to be made from the list of disciplines having established graduate programs.

In addition to formal degree programs, there will be seminars with joint participation of faculty, students and members of local governmental agencies and private industry interested in problems of urban transportation.

Short courses are contemplated to bring to those interested concentrated information on a specific subject.

Advanced Degree Programs

Each graduate student participant in the Urban Transportation Program, after being admitted through normal Graduate School channels*

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*In addition to normal graduate school application forms, each applicant seeking participation in the Urban Transportation Program (with or without financial support) will file a special application.

will be enrolled in an established discipline of his choice with the objective of pursuing a program leading to an established, advanced degree. He will be assigned two advisors by the Administrative Committee of the Interdisciplinary Program in Urban Transportation. These advisors will in general be drawn from the Faculty Advisory Panel. One will represent a technical field and one will represent a socio-humanistic field. Each student will, with the help of his advisors, plan a program of study majoring in the discipline of his choice but with a strong interdisciplinary relevance to urban transportation.

Students participating in the Program in Urban Transportation will be expected to participate in a core seminar described in this document. Other course work relevant to the students' interests will be drawn from regular University courses as discussed herein. Students without previous professional experience in a field related to urban transportation will be expected to engage in an internship at some appropriate agency.* (This internship will usually take place during the summer following the first year of study.) As an adjunct to the internship, students who have not had an opportunity to attend a national meeting of a professional society will be urged to attend such a meeting, and will be reimbursed for the travel involved.

Students studying for the Master's degree will be strongly urged to follow Plan A (the plan which includes a thesis--see discussion under Curricula for Graduate Study). Where feasible, arrangements will be made for thesis research to be conducted in an interdisciplinary manner. The degree received by each student will be that normally conferred in the discipline of his selection. In addition to the normal degree diploma, each student completing a degree under the Program in Urban Transportation will receive an apppropriate certificate.

Curricula for Graduate Study

The University offers both the Master's and Ph.D. in many fields. The Master's degree is normally the M.A. in non-technical

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*Where the site of the internship involves travel, the students will be reimbursed in accordance with normal University travel procedures.

departments, and the M.S. degree in technical departments. There are currently two options for a Master's Degree program:

Plan A - A minimum of 18 quarter credits in the major field and 9 credits in a minor field plus a Master's Thesis.

Plan B - A minimum of 45 quarter credits, of which at least 21 credits are in the major field and at least 18 credits are from at least two related fields with a minimum of 6 credits required in each. Also requires 3 papers (of the quality but not range of an M.S. thesis) in 3 of the courses.

In the near future graduate students in several of the engineering departments will have the opportunity of pursuing studies leading to the Master of Engineering degree, which calls for a design project rather than a thesis. (See Appendix F.)

Curricula for advanced study in urban transportation will normally be "tailored' for each student in relation to his previous training and career objectives.

The Department of Civil Engineering has initiated an M.S. program with a specialization in Urban Transportation. Sample programs for the Master's degree are detailed on the following page. They illustrate the flexibility and wide choice of disciplines open to Civil Engineering students under this option. Similar programs, combining a wide range of options around a disciplinary core, are also available in other technological and social sciences which are joining in this proposal.

An undergraduate design training program also illustrates the cooperative efforts already initiated by three of these departmental faculties (see Appendix C). The design program has been developed by the Departments of Aeronautics and Engineering Mechanics, Civil Engineering, and Mechanical Engineering. One hundred fifty students are involved; faculty is drawn partly from Twin Cities industrial design positions; and the approach to these projects offers opportunity for graduate students to participate both as leaders of undergraduate teams and as advanced seminar members.

Current Course Offerings

A wide spectrum of courses is available for inclusion in

TABLE III - 1

TYPICAL PROGRAM FOR M.S. IN CIVIL ENGINEERING: PLAN A

Fall Term			Winter Term			Spring Term	
	Seminar in Urban Transportation	(3)	CE 130 Introduction to Transportation Planning	(3)	CE 215	Advanced Transportation Planning	(3)
CE 210	Theory of Traffic Flow	(3)	CE 211 Urban Traffic Operations	(3)	CE 212	Freeway Traffic Operations	(3)
QA 151	Elements of Statistics	(3)	IE 198 Design and Analysis of Experiments I	(3)	IE 199	Design and Analysis of Experiments II	(3)
		9		9			9

TYPICAL PROGRAM FOR M.S. IN CIVIL ENGINEERING: PLAN B

Fall Term			Winter Term			Spring Term	
	Seminar in Urban Transportation	(3)	Seminar in Urban Transportation	(3)		Seminar in Urban Transportation	(3)
CE 210	Theory of Traffic Flow	(3)	CE 130 Introduction to Transportation Planning	(3)	CE 215	Advanced Transportation Planning	(3)
CE 158	Airport Design	(3)	CE 211 Urban Traffic Operations	(3)	CE 212	Freeway Traffic Operations	(3)
QA 151	Elements of Statistics	(3)	IE 198 Design and Analysis of Experiments I	(3)	CE 152	Geometric Highway Design	
						or	(3)
					CE 112	Aerial Surveys and Photogrammetry	
IE 130	Introduction to Operations Research	(3)	Geog 167 Location and Geographic Design I	(3)	Geog 168	Location and Geographic Design II	(3)
		15		15			15

Note: As courses in mass transit are developed, they may be substituted as appropriate.

urban transportation programs. The following listing of these courses suggests several disciplines from which major students might bring a highly relevant substantive study of some aspect of the transportation system; but it also suggests the rich variety of supporting fields. It should be emphasized that this list of courses--lengthy as it is--actually contains relatively little overlap and probably falls short of representing the variety of approaches and substantive knowledge required in everyday agency operations. The most important component of this or any program, therefore, is the integrating or core seminar.

Current Courses Relevant to Urban Transportation

Architecture

Arch	131	Planning: Theory and Methodology
Arch	132	Planning: Urban Function and Structure
Arch	133	Planning: Housing and Community Facilities

Business Administration

QA	158	Quantitative Approaches to Administrative Problems
QA	171	Statistical Methods for Sample Surveys
QA	181	Quality Control and Industrial Statistics
QA	191A-B	Statistical Methods in Business Administration
MIS	209A	Introduction to Hardware and Software Systems
Mgmt	150	Fundamentals of Management
Trans	154	Fundamentals of Transportation
Trans	184	Carrier Management

Civil Engineering

CE	130	Introduction to Transportation Planning
CE	151	Advanced Highway Laboratory
CE	152	Highway Design
CE	153	Soils in Highway Engineering
CE	154	Design of Highway and Airport Pavements
CE	156	Highway Traffic Engineering
CE	158	Airport Design
CE	168	Public Works Engineering
CE	210	Seminar in Theory of Traffic Flow
CE	211	Seminar in Urban Traffic Operations
CE	212	Seminar in Freeway Traffic Operations
CE	215	Seminar in Advanced Transportation Planning
CE	280, 281, 282	Civil Engineering Research

Economics

Econ	101	Introduction to Decision Theory
Econ	140	Economics of Location and Transportation
Econ	185A-B-C	Microeconomic Theory
Econ	195A-B-C	Decision Making and Operations Analysis

Electrical Engineering

EE	107-8	Linear System Analysis
EE	129A-B	Control Systems

Geography

Geog	165	Urban Geography
Geog	167-8	American Cities - Location and Geographic Design
Geog	181-2	Statistical and Advanced Cartography
Geog	184	Air Photo Interpretation
Geog	187	Quantitative Research Design
Geog	188	Area Sampling and Analysis
Geog	200 & 301	Directed Reading and Research Problems (Student Choice)
Geog	221-2-3	Seminar: Quantitative Geography
Geog	256-7-8	Land Use Planning
Geog	271-2-3	Historical Economic Geography

Industrial Engineering

IE	100	Introduction to Industrial Engineering Analysis
IE	120	Probability Models
IE	130	Introduction to Operations Research
IE	172	Manufacturing Cost Analysis
IE	133A-134A	Mathematical Models in Operations Analysis
IE	167	Materials Handling
IE	170	Production Planning and Control
IE	171	Quality Control
IE	173	Engineering Economic Analysis
IE	180	Management for Engineers
IE	182	Industrial Safety
IE	193	Introduction to Optimal Control and Dynamic Programming
IE	195-6	Applied Industrial Engineering
IE	198	Design and Analysis of Experiments I
IE	199	Design and Analysis of Experiments II

Law

Law	137	Land Use Planning
Law	140	Administrative Law
Law	148	Seminar: Public Affairs (Legal problems in Minnesota public affairs)
Law	159	Local Government Law
Law	164A	Regulated Industries
Law	193	Seminar: Urban Affairs

Mathematics

Math	133A-134A	Probability with Technological Applications
Math	164-5-6	Theory and Programming of Modern Digital Computers
Math	173-4-5	Elementary Partial Differential Equations
Math	178	Probability
Math	178A-B-C	Introduction to Probability
Math	184	Elementary Numerical Analysis in Engineering
Math	185-6	Numerical Analysis in Engineering
Math	280A-B-C	Mathematics of Computers and Control Devices
Math	285A-B-C	System Programming
Math	293	Information Theory

Mechanical Engineering

ME	123	Creative Engineering
ME	127	Friction and Lubrication
ME	129	Vibration Engineering
ME	146A	An Introduction to Combustion and Propulsion
ME	170	Manufacturing Processes
ME	191-192-193	Mechanical Engineering Design
ME	197	System Analysis and Control
ME	198	Industrial Instrumentation and Control
ME	199	Advanced System Analysis and Control
ME	223	Advanced Vibration Engineering
ME	224-5-6	Advanced Applied Dynamics
ME	296-7-8	Feedback Control Systems

Mineral Engineering

MinE	240	Advanced Concepts in Drilling of Rocks

Political Science

Pol	115	State Government
Pol	116	Introduction to Community Politics

Political Science (Cont.)

Pol	118	Metropolitan Government and Politics
Pol	130-131	Administrative Processes

Public Administration

PA	210	Public Administration and the Political Process
PA	212	Issues in American Public Policy - Transportation
PA	270A	Administrative Theory and Behavior - Transportation
PA	270B-C	Administrative Management - Transportation
PA	280A	Local Administration
PA	281	Law and Urban Affairs
PA	282A-B-C	Administrative Internship (with a Transportation agency)
PA	283	Research (in urban transportation administration)
PA	247	Urban Development
PA	265	Intergovernmental Administrative Relations
PA	284	Individual Reading and Research

Public Health

PubH	153	Principles and Methods of Accident Prevention
PubH	154	Special Studies in Accident Prevention
PubH	155	Introduction to the Air Pollution Problem

Statistics

Stat	121-122-123	Theory of Statistics
Stat	131-132-133	Theory of Statistics
Stat	191-192-193	Analysis and Design of Experiments
Stat	194	Introduction to Correlation and Multivariate Analysis

Sociology

Soc	111	Population Theory
Soc	115	Social Aspects of Housing and Standards of Living
Soc	145	Urban Sociology
Soc	245-246	Seminar in Urban Sociology

Proposed New Courses

Core Seminar

All students of urban transportation, regardless of discipline, will be expected to participate in an Interdisciplinary Seminar in Urban Transportation. This seminar will be organized by the Program in Urban Transportation, and will include students, faculty and participants from government and industry. (Students will receive degree credit by enrolling under appropriate general seminar course numbers in their respective departments.) The seminar will give heavy emphasis to problems of interaction and communication in planning, research, and execution of plans and also to the development of familiarity and mutual understanding of the various techniques and systems involved in the solution of urban transportation problems.

It is proposed that the Interdisciplinary Seminar in Urban Transportation continue throughout the academic year, with meetings approximately bi-weekly. Lectures will be presented by faculty members and by guest speakers drawn from agencies and private business concerned with urban transportation, not only in the Twin City area, but also from across the nation. Each graduate student participant will be asked to present a paper at an appropriate time.

This seminar series will be developed and conducted under the guidance of the Administrative Committee of the Program in Urban Transportation. Funding will be needed to cover visual aids and honoraria for special speakers.

Other New Courses

Several new courses will be proposed to fill gaps which some students in urban transportation may find in the existing course structure. Courses currently proposed are:

Civil Engineering	Analysis and Functions of Transportation Systems: Study of characteristics common to all transportation systems as well as characteristics which differ; methods of classifying characteristics and functions of transportation systems.

Geography	Transportation Geography: Areal principles and functions of transportation networks; historical and national variations in modal developments; commodity and passenger flows; case studies of regional and local systems.
Mechanical Engineering	Technology of Advanced Transit Systems: Intensive study in application of modern technology to new transit systems; morphological approach to design of fixed-track systems; methods of analyzing propulsion and suspension systems.
Mechanical Engineering	Technology of Mass Transit Systems for Non Engineers: Same as above course but treatment will be more qualative and less analytical.
Psychology	Principles of Bio-engineering: Introduction and discussion of feedback control theory in man-machine interactions; human engineering methodology and data relative to the capacity of the human operator in a variety of control-display relations.

Experimental Training in Mass Transportation System Design

This is an experimental laboratory course involving both graduate and undergraduate students. Its evolution out of an undergraduate design program led by the Mechanical Engineering faculty is discussed in Appendix C. Students and faculty from pertinent disciplines will work together as teams on practical transportation-system design problems. Principles of management which contribute to the success of these large-scale multidisciplinary programs will be identified.

Short Courses

Special short courses will be arranged from time to time on

the advice of the Agency Advisory Panel to bring to concerned personnel specialized information in a particular phase of urban transportation. In general these courses will be expected to be self-supporting. The Center for Urban and Regional Affairs will make up any deficit that might develop for a particular course. (The course currently planned for March, 1969, will provide experience to serve as a basis for planning of future courses.)*

Financial Support for Students

In order to encourage highly qualified students to direct their efforts and interests toward urban transportation, it is proposed that there be a group of fellowships to be offered to such students. In addition, it is proposed that a limited number of special fellowships be provided in order to enable persons engaged in the practice of some aspect of urban transportation to take leave for one or two years and pursue advanced training programs.

In addition to fellowships for the most highly qualified students, other students may receive financial assistance in the form of Research Assistantships.

The fellowships proposed are as follows:

Type A (for recent recipients of the Bachelor's degree):
$3300 for an academic year of 9 months plus as allowance of $500 per dependent (up to a maximum of 3 dependents) plus tuition and incidental fees,** plus $75 per year for books and supplies.

Type B (for holders of the Master's degree):
$4000 for an academic year of 9 months plus an allowance of $500 per dependent (up to a maximum of 3 dependents) plus tuition and incidental fees,** plus $75 per year for books and supplies.

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*A course for traffic technicians is being planned for the 5-day period starting March 17, 1969. This course is being presented at the request of the Minnesota Highway Department and several local jurisdictions. It is expected that enrollment will include persons from other states in the Upper Midwest.

**Currently tuition and incidental fees are $403.50 per academic year for residents of Minnesota and $931.50 per academic year for non-residents.

Type C (for professional persons in urban transportation returning for advanced training:

2/3 of annual professional salary (subject to the limits defined below) plus tuition and incidental fees, plus $75 per year for books and supplies.

The limit of the stipend under this type of fellowship will be computed as follows:

9-month academic year	summer (if applicable)
$6500 plus $500 per dependent up to 3 dependents	$2167 plus $167 per dependent up to 3 dependents

Internships

Internships will normally be required of recipients of Type A fellowships. These internships will provide important experience to the students, and will normally be of 3 months duration. During this period it is proposed that each student receive a stipend of $2200 plus $167 per dependent up to 3 dependents. In some cases the Agency providing the internship may have funds to pay the student stipend. Where this is not the case, the stipend will be paid by the Program in Urban Transportation. Many contacts already exist for development of these internships. For example, the School of Public Affairs has had internships in transportation administration arranged with the state and metropolitan highway and transportation agencies in this metropolitan area.

Summer Employment

It is expected that students receiving Type A Fellowships will be engaged in internships during their first summer. During other summers it is expected that they will be employed as research assistants. It is expected that holders of Type B Fellowships will be engaged as research assistants during summers.

Selection of Recipients of Fellowships and Internship Stipends

The selection of fellows and recipients of internship stipends will be made by the Administrative Committee, according to the following criteria. In each class, selection of fellowship recipients from the group of applicants will be made on the basis of the relative qualifications of the applicants. There is no pre-set quota by discipline:

Recent Recipients of the Bachelor's Degree:

Interest in urban transportation and promise of outstanding future contributions as indicated by an excellent academic record and letters of recommendation from professors and from supervisors of part-time employment, if any.

Holders of the Masters Degree:

Interest in urban transportation and promise of outstanding future contributions as indicated by excellent academic record, letters of recommendation, copies of master's thesis or other master's degree reports, and copies of publications, if any.

Candidates Returning from Professional Practice:

Attention will be given candidates' academic records; but emphasis will be placed on letters of recommendation, copies of reports, designs, publications, etc., as evidence of superior performance and interest in urban transportation.

Proposed Number of Fellowships and Internship Stipends

The following numbers of fellowships are proposed:

	1969-70		1971-72		1972-73	
	Number	$	Number	$	Number	$
Type A	6	29,250	6	29,250	6	29,250
Type B	6	33,450	12	66,900	6	33,450
Type C	3	32,229	6	64,458	3	32,229

Proposed Number of Fellowships and Internship Stipends (Cont.)

	1969-70		1971-72		1972-73	
	Number	$	Number	$	Number	$
Internships	6	16,206	6	16,206	6	16,206
		111,135		176,814		111,135

(Note: The amounts shown above are computed at the maximum payable under each category.)

Summary

In short, the proposed program emphasizes the more effective use of talents and faculty now at work in the University through coordinated advising, core seminars, jointly operated internships and problem studies. There is a special effort to provide the greatest possible flexibility and encouragement of individual initiative and creativity.

IV. RESEARCH PROGRAM

While research always has the objective of advancing knowledge, within the University it has certain additional objectives, including:

1. Providing a continuing source of information to keep instruction fresh.

2. Serving as an important part of the experience of the advanced student by giving him the opportunity to participate in the search for new ideas.

3. Providing techniques whereby other agencies can solve specific problems.

Within the proposed Program in Urban Transportation, research is expected to play all of these roles. To this end it is proposed that several projects related to urban transportation be undertaken. These projects have been grouped into the following broad categories:

Forecasting future transportation demands

Problems in urban mass transit

Other problems of urban transportation.

The following table lists the proposed projects under each of these categories. Descriptions of the projects follow the table in alphabetical order according to project designation.

TABLE I.

General Category	Project Designation	Project Title	Principal Investigator	Department
Forecasting Future Transportation Demands	Econ 1	Location-Transportation Interaction and the Modal Split Problem	Herbert Mohring	Economics
	CE 1	Forecasting Demand for Transportation and the Relationship to the Design of Transportation Facilities (Effects of Various Levels of Estimating Precision)	Matthew J. Huber	Civil Engineering
	Geog 1	Forecasting Areal Demand for Suburban Mass Transportation	Russell B. Adams	Geography
	Econ 3	Value of Travel Time in Urban Transportation Studies	Herbert Mohring	Economics
Problems in Urban Mass Transit	Econ 4	Quantification and Justification of Mass Transit Subsidies	Herbert Mohring	Economics
	ME 2	Operational Characteristics of Mass Transit Systems	John Edward Anderson	Mechanical Engineering
	EE 1	Theoretical Studies of Mass Transit Systems	K.S.P. Kumar	Electrical Engineering
	ME 3	Engineering Problems in Urban Mass Transit Systems	John Edward Anderson	Mechanical Engineering

TABLE I. (cont.)

General Category	Project Designation	Project Title	Principal Investigator	Department
Other Problems of Urban Transportation	Econ 1	Optimal Utilization of Airports: Congestion, Pricing and the Near-Far Problem	Herbert Mohring	Economics
	ME 1	Study of the Dynamics of Interaction Points Coupling Transportation Modes	Darrell A. Frohrib	Mechanical Engineering

Project CE 1: FORECASTING DEMAND FOR TRANSPORTATION AND THE RELATIONSHIP TO THE DESIGN OF TRANSPORTATION FACILITIES

Objectives of the Project

Transportation systems, because of the permanency of the right-of-way and the large capital investment in structures and facilities, are built to anticipated demand for periods of twenty to thirty years in the future. In highway transportation planning in particular, there has come into being a procedure for forecasting urban travel demand for some future year. Such procedures require a substantial investment of time and money in order to develop what is considered a minimum input for the planning process. The engineer designs the transportation facility to provide sufficient capacity to meet the forecast demand.

The objective of this study is to review past performance in transportation forecasting, particularly on highways and streets, comparing existing operation and demand levels to those forecast at some past time. The purpose is not to question the forecasts made in the past (techniques used as recently as five or six years ago were very crude and practicioners of the art at present question their own results), but rather to investigate the consequences of discrepancies between forecast and actual values. The particular purpose will be to relate the required precision of data needed for transportation planning to the type and cost of data collection used to provide the necessary input to the planning process.

Problems to Be Investigated

During the first year of the study there will be a review of previously forecast and currently existing volumes on selected highway facilities particularly in states of the upper midwest. This will require a selection of existing facilities for which forecasts were made, a review of the volume forecasting technique and a survey of current volume. What is the nature and magnitude of variations between actual and forecast volumes? To what magnitude do these variations influence the present operation of the highway system? Are the existing magnitude and variations

in volumes what might have been anticipated at the time the forecast was made? It is recognized that the number of roadway segments for which sufficient data are available might be limited because many roadways currently in operation were built without the need or use of sophisticated planning techniques. Those roadways which were planned with more sophisticated techniques are not completely constructed or have been in operation for such a short time as to preclude the development of historical data.

This phase will be conducted by contacting various highway departments and urban transportation planning agencies in the upper midwestern states for access to information about forecasting techniques used and historical results of various transportation planning projects. This data collection phase will require observations of present levels of operation (vehicular volumes or passengers per day or peak hour) as compared to forecast values. Further analysis of operating conditions (congestion, delay and travel time) will be required to evaluate discrepancies between observed and forecast values. It is anticipated that much of the information is presently available in records of the appropriate agencies and that on-site data collection will be minimized.

During the second and third years of the project the data collected during the first year will be collated and analyzed with the objective of making a critical review of the precision necessary for transportation planning. A study of incremental changes in forecast volume and the consequent influence in design of a highway or a highway network will be made. At what volume difference does it become necessary to redesign a highway, to add or subtract traffic lanes? How much variation from forecast volume can be tolerated by a change in level-of-service from that initially planned? How much "surplus" capacity is introduced by a decision to add one lane to a roadway and how does this relate to tolerance in forecasting future volumes.

Are these tolerances in capacity of a roadway sufficient to permit less precise volume forecasts? If so, is it possible to decrease the sampling rate for transportation studies or to suggest new techniques for volume forecasting.

It is further anticipated that the review and analysis of precision requirements will have direct application to planning other modes of transportation with capacity characteristics which are different from those of highways.

Personnel Requirements

First Year

Principal Investigator (Matthew J. Huber)
1/4 time, 9 months
full time, 2 months (summer)

Research Assistants
One, 1/2 time, 9 months
One, full time, 3 months.

Second and Third Year requirements will be the same.

Plans for Publication

The final report of the project will be published by the Center for Urban and Regional Affairs of the University. Pertinent sub-sets of the study will be presented to professional organizations such as the Highway Research Board.

Travel

Travel will be required for data collection and presentation of technical papers.

Project Econ 1: LOCATION-TRANSPORTATION INTERACTIONS AND THE MODAL SPLIT PROBLEM

Summary

The goal of the project is to apply simultaneous equations econometric techniques to analyze data generated by the Survey Research Center at the University of Michigan on household location, land use, auto ownership and travel patterns. The analysis is aimed at isolating the structural demand relationships underlying household choices of travel modes and, to the degree possible, to explore the interrelationships between transportation system characteristics and land use patterns.

The Problem

The procedure typically followed in urban transportation planning studies is about as follows: first, current land use patterns and the trip generation rates observed to be associated with land use types are projected into the future. Second, trips are distributed--typically by use of some sort of gravity model--between travel zones. Third, interzonal trips are split between public and private transportation modes and are then assigned to existing or proposed traffic arteries. Fourth, arteries with capacities insufficient to meet the demands projected for them are identified and plans are made to improve them.

This procedure has a number of important deficiencies. First, while land use does affect the demand for trips, attributes of the transportation system also affect land use. More generally, the nature of the transportation system, the uses (residential, commercial, industrial, etc.) to which urban land is put and the intensity with which it is utilized, the number and types of trips taken between pairs of points, and the way in which these trips are split between public and private transportation modes are interrelated phenomena.

Second, the planning procedure at most partly takes into account the fact that the rate at which trips are taken between any two zones depends not only on land use in them but also on the time and money costs of travel between them. That is, it

fails finally to take into account the fact that transportation improvements will lead to increased travel even holding land use constant.

Third, existing predictive models almost invariably involve "reduced forms." That is, they involve relationships fitted to observations determined by the intersection of demand and supply schedules. They do not involve the underlying demand and supply schedules themselves. For example, the fraction of trips between two zones that will be taken by mass transit is typically predicted by a single least-squares regression relationship fitted to data on, inter alia, zonal median income, auto ownership, and some measure or measures of the relative time and money prices of trips by the two modes.

Nature and Current Status of the Research Project

Each of these deficiencies involves the potential for perhaps substantial error in predicting the uses that will be made of urban land and of existing and proposed components of urban transportation systems. Given the necessary data, use of simultaneous equations statistical estimation procedures would likely make it possible to reduce substantially these potential errors in prediction. Two surveys undertaken by the University of Michigan's Survey Research Center under Bureau of Public Roads auspices provide data which should enable quantifying the structural relationships underlying the choice of modes and possibly some of the other relationships involved in the interactions between land use and transportation systems.

Thomas Pinfold, a graduate student in the University of Minnesota, Economics Department, is now using the SRC data to undertake a simultaneous equations study of the modal split problem for his doctoral dissertation. He is currently supported by a Canada Council fellowship, which covers living and tuition expenses. However, no money is available in his fellowship to cover data processing and related expenses. Also, the fellowship expires in June 1969. The problems on which he is working are sufficiently complex and the SRC data sufficiently comprehensive that funds enabling him to continue his research through the summer of 1969 promise to yield handsome returns.

Personnel Requirements

Faculty Supervisor (Herbert Mohring)

Graduate Student Investigator (Thomas Pinfold)
Full time, 3 months (summer)

Reports

Results will be reported in a Ph.D. dissertation. It is expected that this dissertation will be distributed as a report of the Center for Urban and Regional Affairs. As appropriate, one or more papers will be prepared for professional journals.

Project Econ 2: OPTIMAL UTILIZATION OF AIRPORTS: CONGESTION PRICING AND THE "NEAR-FAR" PROBLEM

Summary

The goal of the project is to use queueing theory to analyze data being provided by the Department of Transportation on delays and other aspects of the use of Washington National, Dulles and Friendship Airports to infer both an optimal pricing system for use of these airports and the magnitude of the resource misallocation resulting from current pricing procedures.

The Problem

As with most economic activities, the short-run marginal social cost of an air trip is an increasing function of the output/capacity ratio of the airport through which it is taken. This cost increases mainly because an increase in traffic intensity adds to the time spent waiting for clearance to land or take off, searching for a parking space, standing in line to be checked in, waiting for baggage, hailing a cab, or driving into or out of the airport. These delays increase exponentially as output approaches capacity. They increase trip-time costs to travelers, and they also increase airline fuel and crew costs by adding to the time planes spend circling or sitting on the ground waiting to take off. More important, they lower seat-mile output per aircraft hour.

Because delays increase directly with the output/capacity ratio, it follows that every additional flight or passenger through an airport adds slightly to the delay experienced by every other flight and passenger. But in the absence of a toll, the passenger or airline is not required to take these "imposed" delays into account; hence, the private cost of a trip is less than the full marginal social cost. Optimizing the use of airports requires the collection of a congestion toll equal to the difference between marginal social cost and average variable cost (where both cost functions include the value of time inputs as well as the value of market inputs).

Since demand for airport utilization varies throughout the day, by day of week, and seasonally, to satisfy the "price equals

marginal social cost" dictum would require congestion tolls that vary over time. Implementation of (Pareto) optimal congestion tolls which vary in this way would allocate traffic efficiently over time. Consider, for example, the distribution of flights presently handled by airports in a typical day. The distribution is usually bimodal, with a morning peak about 8:00 A.M. and a higher peak in the afternoon about 5:00 P.M. During some hours of the day, however, even the largest airports handle very little traffic. Social marginal-cost pricing would make it more expensive to fly, say, at 5:00 P.M. than at 10:00 P.M. and some people would be expected to shift from the peak period to an off-peak period. The peaks in the traffic distribution would become flatter. Given today's traffic, an airport could handle more traffic than it does presently without increasing the average delay it is experiencing during its peak hour.

Airspace in and around metropolitan airports is a natural facility that cannot be expanded. Suppose congestion pricing is being used for efficient allocation of a single airport, but increasing delays, rising costs of operation, and accident hazards make it desirable to construct an additional airport. Building of more airports does not increase air space unless they are well separated from old airports. If they are, on the other hand, then another problem is aggravated--the long period of time required to get from the terminal to the downtown area. Probably the best example to be found of this phenomenon is Washington-Baltimore.

At present, the fares from a given point in the United States to Washington National, Dulles and Friendship airports are the same. For travelers with downtown Washington destinations, both the time and the dollar costs of trips through Dulles or Friendship are greater than those through National. Such travelers form a sufficiently large fraction of those who travel to Washington that both terminal and landing facilities at Washington National are operating virtually at "capacity"* while substantial excess capacity exists at both Dulles and Friendship.

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*Actually, the demand for service at Washington National at the going price exceeds the "capacity" output of the airport. Were it not for a non-price rationing system initiated by the FAA, the cost of delays at the airport would be even greater than they presently are.

Thus, average costs are lower for passengers and possibly (given the higher load factors involved) for airlines on trips through Washington than they are on trips through Dulles or Friendship. On the other hand, marginal social costs almost certainly are higher at Washington National than at Dulles or Friendship. It is quite likely that a substantial saving in resources could be realized if some trips currently being made through Washington National were diverted to Dulles and Friendship. This assertion is widely accepted. The question is how such shifts should be effected.

A variety of specific proposals for shifting trips have been made. These can be broken into two categories: those which would re-allocate traffic through reliance on the price system and those which would re-allocate by decree. Consider how the price system could do the job.

Suppose the aggregate dollar outlay required to land at Washington National and travel to downtown was increased so that it was higher than the corresponding dollar outlay for a trip through Dulles (or Friendship). Given a choice between the two arrival points, those travelers who place relatively low values on their time would voluntarily shift to Dulles (Friendship) while those who value time relatively highly would continue to choose Washington National. Some few individuals would value time such that they would be indifferent between saving time by traveling through Washington National and saving money by traveling through Dulles (Friendship).

If an increase in the difference between the dollar price of trips through the two (three) airports were made, the proportion of all Washington travelers who would choose Dulles (Friendship) would increase, and the identity of the indifferent travelers would shift to persons with higher time values. An increase in the number of Dulles (Friendship) travelers, on the other hand, would result in an increase in the marginal social cost of a Washington National trip. The "ideal" price differential would vary through time in keeping with congestion pricing rules, being relatively great at peak travel hours and relatively low at other times of the day.

Nature and Current Status of the Research Project

James Likens, a graduate student in the Department of Economics at the University of Minnesota, is presently doing research on these issues for his doctoral dissertation. He is determining the actual prices that would bring about (Pareto) optimal utilization of the Washington-Baltimore airports, taking into account both congestion pricing and the "near-far" problem. He will use these results to estimate the welfare costs of the present sub-optimal utilization of airports.

He is utilizing queueing theory, empirical delay data collected by the CAB in the Washington-Baltimore Investigation (Docket 18712), and the Washington-Baltimore Airport Access Survey prepared for the Department of Transportation by Abt Associates, Inc.

The importance and timeliness of this research is obvious. Likens is having difficulty completing it quickly, however, because he has no direct research support. He currently is teaching half-time at Minnesota, but his assistantship ends in June 1969. Funds which would make it possible for him to work on this project full-time through the summer of 1969 would be most productive.

Personnel

Faculty Supervisor (Herbert Mohring)

Graduate Student Investigator (James Likens)
Full time 3 months (summer)

Reports

Results will be reported in a Ph.D. dissertation. It is expected that this dissertation will be distributed as a report of the Center for Urban and Regional Affairs. As appropriate, one or more papers will be prepared for professional journals.

Project Econ 3: THE VALUE OF TRAVEL TIME IN URBAN TRANSPORTATION STUDIES

Summary

The goal of the project is to apply standard statistical techniques to the Survey Research Center data mentioned in the discussion of Project Econ 1 to infer the direction and magnitudes of biases involved in previous attempts to estimate the value travelers place on time in transit from information on real estate prices.

The Problem and the Research Project

A knowledge of the money value travelers attach to time they spend en route is of considerable importance both in optimizing the design of transportation facilities and in predicting the demands for new transportation system components. Inferring the value of travel time is difficult because no markets exist in which it is bought and sold directly. There are, however, several markets in which travel time is among the commodities traded. Thus, in choosing between a relatively slow trip by mass transit and a more rapid but also more expensive private passenger vehicle trip, a consumer is, in effect, trading time for money. Similarly, in choosing between two residences, one at some distance from his downtown office, another closer to it, a commuter is, in part, trading lower cost land for journeys to work that are both more expensive and more time consuming.

In at least two studies* attempts have been made to infer the value of travel time from the relationship between real estate prices and travel time to some dominant focus of economic activity--the central business districts, of Seattle, Washington in one case and of Washington, D.C. in the other. Both studies came up with grossly implausible results: the decline in land

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*Herbert Mohring, "Land Values and the Measurement of Highway Benefits," The Journal of Political Economy, LXIX, No. 3, June 1961, pp. 236-249 and William C. Pendleton, The Value of Highway Accessibility, unpublished doctoral dissertation, University of Chicago, 1963.

values with distance was more than accounted for by the associated increases in vehicle operating costs, by moving further from the CBD, commuters actually appeared to be paying a premium for increased travel time.

A variety of factors suggest themselves as explanations for this perverse finding. Perhaps most important is the possibility that the presence of desired attributes of residences--e.g., proximity to open space, distance from slums surrounding the CBD, putatively superior suburban schools, lower tax payments for welfare programs--are negatively related to distance from the CBD. In addition, however, in both of these studies, data problems made it essential to work with the assumptions that people do not differ in the values they attach to travel time and that the demands for land trips to the CBD are independent of the prices of these commodities.

It can fairly easily be shown that the obvious invalidity of these latter assumptions serves to bias the estimated values of travel time in a direction that, unfortunately, cannot be specified without knowledge of the correlations between, e.g., trips to the CBD and land use per dwelling unit. The Survey Research Center data provide a basis for estimating both the direction and the magnitudes of the biases involved in the earlier studies. In addition, they may make it possible to infer characters of the population distribution of travel time values other than the mean-- the standard deviation, in particular. Analysis of the Survey Research Center data with these goals in mind would require about one month of senior staff time.

Personnel Requirements

Principal Investigator (Herbert Mohring)
Full time, one month

Project Econ 4: QUANTIFICATION OF ECONOMIC JUSTIFICATIONS FOR URBAN MASS TRANSIT SUBSIDIES

Summary

The immediate goals of the research project are to develop models of use in specifying the optimum size, type and spatial distribution of urban transportation facilities and to use these models as the basis for developing procedures to estimate both the social costs involved when optimum investment and pricing procedures are not employed for urban transportation activities and the magnitude of the possibly desirable mass transit subsidies that stem from the existence of scale economies and non-optimal pricing and investment procedures. Numerical illustrations of these models are being developed using data presently or prospectively available for the Twin Cities Metropolitan Area. The models and the theoretical work underlying them should prove directly applicable to the transportation problems of other urban areas and, with suitable modification, both to other problems involving the optimal spatial distribution of activities that involve scale economies and to other optimization problems involving multiple characteristic commodities whose production is subject to increasing returns.

The Problems

A considerable body of theoretical and empirical work has accumulated on the characteristics of an optimum pricing system for existing transportation networks. Most writers on the subject seem to agree that achieving Pareto-optimality would require each auto operator to pay not only the costs he bears himself but also a toll equal to the costs his trip imposes on other travelers by adding to the level of highway congestion. Strotz (10) and Mohring (5, 7) have proved a proposition that can be expressed in the following terms: In the absence of scale economies, employment of two quite simple operating rules would lead to both a Pareto-optimal utilization of an existing (perhaps non-optimum) transportation network and, ultimately, a long run optimum network. These rules are: a) establish short run marginal cost prices for each user--each subway, bus or private passenger vehicle traveler--of each link in the existing network; and b) alter the size of each link to the point where toll revenues equal the costs to the authority of providing that link--

maintenance and other operating costs, depreciation, and imputed interest on invested capital. In the absence of scale economies, each component of an optimum transportation system would be exactly self-supporting. A definite welfare loss would result were any component of the system to be subsidized.

Factors do exist, however, that make this "no deficit" financing principle inapplicable to current and possibly to prospective urban transportation systems. These factors can usefully be grouped under two broad headings: a) non-optimum pricing and investment policies; and b) the presence of scale economies in the provision of highway and, to an even greater degree, mass transportation facilities. A third set of factors that might obviate the "no deficit" principle--externalities in the provision and use of transportation facilities--will not be dealt with in the proposed study.

The several published studies (see e.g., 1, 6, 11) that have a direct or indirect bearing on optimum highway toll structures seem to agree in one very important respect: The optimum toll increases rapidly with the ratio of the actual number of trips being made on a street or highway to the maximum number that could be made. To take an extreme example, it has been estimated that the optimum tolls for the average Twin Cities Metropolitan Area (TCMA) street were approximately 0.2 and 19.1 cents per vehicle mile respectively between 2:30 - 4:00 a.m. and between 4:30 and 5:00 p.m. on the average 1958 weekday (6). Gasoline taxes--the principal highway user "toll"--averaged out to about 0.5 - 0.7 cents per vehicle mile and do not vary appreciably with traffic levels. This being the case, the general financing principle noted above would seem to support an expanded highway construction program. Indeed, (7) reports estimate that the marginal rate of return on new freeway construction in the TCMA may be as high as 300 percent and that currently planned freeway construction falls far short of the level necessary to equate optimum tolls with capital costs in the TCMA. Therefore, since the contribution to highway congestion of a bus rider is considerably smaller than that of an automobile passenger, a mass transit subsidy program might very well prove desirable, at least in the short run.

A variety of systems have been suggested for varying tolls on urban transportation facilities through the day. All of them present substantial--perhaps insuperable--legal, political, and/or cost obstacles. As a matter of general principle, if it is impossible to establish marginal cost prices in one line of activity, the best alternative pricing system would not necessarily entail marginal cost prices for the remaining activities. This "second best" consideration may also tend to support mass transit subsidies.

Neither the economics nor the transportation literature seems to contain much quantitative information on the magnitude of scale economies in the construction and maintenance of highway networks. Fairly obvious scale economies do seem to exist, however. For example, the cost of paving six lane expressways is less than 150 percent of that for four lane expressways. The same considerations apply to overpasses and to the amount of land required for rights of way.

As for mass transit services, the limited available evidence suggests that costs per seat mile decrease substantially with increases in bus size. For this reason, the provision of mass transit services involves perhaps substantial scale economies. Once a rider is aboard a bus, an increase in the number of passengers very likely increases his time en route by increasing both the number and the duration of stops. At the same time, however, an increase in the demand for trips on a route would likely result in increased service frequencies and therefore in reduced waiting time. Some rough estimates suggest that the scale economies associated with increased service frequencies imply an optimum mass transit subsidy in the TCMA equivalent to roughly 10-20 percent of current mass transit fare revenues.

Objectives of the Research Project

The models that have been and will be developed to estimate welfare losses and optimum subsidy policies are closely related to those described in part C of (6) and section III of (8). As an example, one of these involves the assumptions that the same price must be charged in peak and off-peak demand periods, that freeway construction costs are on the order of those which prevail in the TCMA, that a relationship exists between the volume/capacity ratio on the one hand and vehicle operating and travel time costs on the other which approximates the results of a number of empirical studies with reasonable precision, and that total system revenues must exactly cover total system costs. The measure of welfare loss developed can be interpreted roughly as the fraction of resources devoted to the production of trips which is, in effect, wasted in the sense that elimination of the pricing constraints would make it possible to devote these resources to other activities without reducing the level of utility derived from trips. For the combinations of cost and demand parameters that have been tested, this welfare loss measure runs between about 0.5 and 25 percent.

The models which have so far been developed incorporate only one transportation mode and do not adequately reflect a number of important ramifications of the facts a) that, in the real world, origins and destinations are distributed through space b) that, because of the existence of scale economies and indivisibilities, the costs of providing both highway and transit facilities with a given capacity increase both with increases in the frequency with which access to them (in this form, for example, of freeway interchanges and transit stations) is provided and with decreases in the spacing between them, and c) that consumers differ in the monetary values they place on each of a variety of non-monetary attributes--time in transit, in particular--of the trips they take.

To elaborate, neither the first nor the third fact mentioned above would pose any problems in a constant returns to scale world. In such a world, it would be possible to connect each origin-destination pair with a sufficient number of transport facilities to meet the exact travel time and other specifications of each customer group. That indivisibilities and scale economies do exist forces compromises to be made: In general, the cost of a given number of passenger or ton miles of transportation capacity decreases as the size of the individual facilities providing them increases. However, reducing capacity costs in this fashion carries with it the penalties both of increasing the circuity of travel by requiring each facility to serve a larger number of origin-destination pairs and of reducing the number of consumer groups whose specifications can exactly be met. Thus, it seems meaningful to talk of optimizing both the number of types of transportation service provided and the circuity involved in a given service.

This optimization problem can probably most effectively be dealt with by exploring the implications of scale economies and indivisibilities for Pareto-optimality within the framework of consumer theory suggested by Lancaster (2, 3). That is, its solution can perhaps most easily be found by developing the characteristics of Pareto-optimality in a world in which a) a consumer values an individual good not in its own right but rather because of the characteristics it possesses (e.g., size, color, horsepower, nature of trip, etc. for an automobile), b) individual consumers differ in the relative utilities they attach to different characteristics, and c) the average cost of manufacturing an individual commodity (e.g., autos each with the same size, color, horsepower, etc.) decreases with the number manufactured.

The broad goals of the research programs, then, are:

a) to undertake the general theoretical exploration suggested in the preceding paragraph;

b) to apply these conclusions to relationships between, on the one hand, the capital and operating costs of various types of transportation facilities (city streets, expressways, bus, and various forms of rapid transit service) and, on the other, their size, spacing, and the frequency with which access to them is provided that will be developed as part of the research program described by the Mechanical Engineering Department to specify the characteristics of optimum transportation networks in hypothetical urban areas differing in origin-destination densities and in such attributes as the population's distribution of travel time values; and

c) to determine both the changes in transportation network characteristics called for by various non-optimum pricing and financing schemes and the welfare losses associated with these elements of non-optimality.

Numerical illustrations are being developed in the course of undertaking steps b) and c). These are, to a large degree, based on data from the TCMA that are either presently at hand or can be obtained fairly easily from the Metropolitan Transit Commission, the State Highway Department and the Metropolitan Council.

Present Status of the Research Project

The research project described above is currently being undertaken with the support of a two year award by the National Science Foundation which began in September 1967. The results of the project to date are summarized in (8) and (9). A revised version of the theoretical portions of (8) together with an article by Mohring and two of the research assistants who have participated in the project, Thomas Pinfold and Marvin Kraus, elaborating on the discussion in (8) of empirical results will be submitted for publication in early 1969. A revised version of (9) will appear in a volume of conference proceedings to be published by the University of Wisconsin Press. In addition, Pinfold's doctoral dissertation (described more fully under Project 1 above), currently being supported by a Canada Council fellowship, was initiated as part of his service as research assistant on the project during the 1967-68 academic year. It

is expected that most of the research assistants involved in the project will both find it possible to and be interested in using their work as the basis for their doctoral dissertations.

The research is mainly being carried out in the University of Minnesota's Center for Economic Research established in the fall of 1965 with the support of the National Science Foundation. In addition to excellent office and conference facilities for research personnel, the Center houses a valuable and growing research library. The project is making use of CDC 3200 and 6600 and IBM 1620 computer systems at the University and is relying heavily on the advice of unusually able groups of applied mathematicians associated with these facilities, of mathematical economists in the Department of Economics, and of members of the University's Mechanical and Electrical Engineering Departments whose interests in transportation problems are described in some of the other research proposals which accompany this discussion.

In applying for the grant, it was expected that at most one additional year would be required to complete the project on expiration of the NSF award in the fall of 1969. Unfortunately, both the substantial reduction in NSF research allotments resulting from recent Federal Government budget cuts and substantially greater difficulties than had been anticipated in programming numerical models have combined to make progress less rapid than had been anticipated. It appears at present that, by September 1969, only rather simple multi-mode constrained optimization models will have been developed and analyzed. However, with an extension of the project at approximately its initially planned level through the summer of 1971, it should prove possible substantially to complete the work described.

Personnel Requirements

First Year

Principal Investigator (Herbert Mohring)
1/2 time during academic year
full time (summer)

Research Assistants
Two assistants
1/2 time during academic year
full time 3 months (summer)

Senior Secretary
1/4 time

Second Year

Same as first year

Reports

Results will be reported as a technical report of the Center for Urban and Regional Affairs. As appropriate, one or more papers will be prepared for professional journals.

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(9) _____, "Urban Transportation Improvements and the Spatial Distribution of Land Values," presented at the Seventh Annual Conference of the Committee on Taxation, Resources, and Economic Development.

(10) Strotz, Robert H. "Urban Transportation Parables," in Julius Margolis, Editor, The Public Economy of Urban Communites. Washington: Resources for the Future, Inc., 1965.

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Project EE 1: THEORETICAL STUDIES OF MASS TRANSIT SYSTEMS

Objectives of the Project

In recent years, a considerable amount of concern has been shown in trying to develop urban transportation systems that fulfill many important needs. Convenience to the user, economical operation, less pollution of the atmosphere are some of the many factors that should be taken into account in the design of any urban transportation system.

Unlike the rapid transit systems that are being studied for the eastern and the western parts of this country, the midwest requires a slightly different approach because the territory is widespread in contrast to the corridor type of territory of the coastal areas. What is needed is an efficient transportation system for the midwestern cities and a high speed connecting link among the various large midwestern cities. Another aspect that exists in the midwest is that the density of traffic is not as high as it is in either coast.

Electrical engineers have studied power scheduling and information transmission problems for many years. Efficient techniques to handle these problems have been developed. At an abstract level, the transportation problem can be viewed as a collection of sources and sinks with an interconnecting network. Techniques from power system scheduling can be used to study the traffic flow along a given network. When this is done, ways to design a network to maximize flow can be studied. Needless to say, every effort must be undertaken to minimize the discomfort to the existing society. For example, any transportation system should not separate existing neighborhoods (as has happened in several cases); it should not contribute to excessive noise in the existing neighborhoods, etc.

As a first step of research in this direction, it is proposed to study via mathematical models and simulation techniques the traffic around the University area and gradually extend the study to the entire metropolitan area. Efficient means of storing urban topographical data on a computer will be developed. Data such as street maps, one-way streets, parking areas, traffic congestion spots have to be stored.

Various mathematical tools such as dynamic programming and theory of queues will be employed. Questions such as the allocation of vehicles, small vehicles versus large vehicles, many stop routes versus large vehicles, many stop routes versus non-stop routes, fixed route-fixed schedule service versus demand activated route scheduling can be effectively studied via simulation techniques. It is quite clear that meaningful simulation is the experimental tool that should be fully exploited.

Every effort will be made to make the engineers aware of the sociological problems. This will be accomplished by a program of interdisciplinary course work.

First Year Study

In the first year of the work, one graduate student will model the transportation on the campus as a network of interconnected nodes. The problem of transferring a vehicle from one node to another in minimum time under the constraints of allowable speed limit, one-way street configuration, etc. will be studied. The minimum time algorithm can best be studied via dynamic programming.

This program will be complementary to that of the Mechanical Engineering program and will not duplicate their research effort.

Second Year Study

Having determined the minimum waiting time algorithms during the first year of study, efforts will be devoted to the concept of a centralized computer despatching system. The problem is to organize a central computer which will schedule buses so that a maximum number of customers can be serviced with minimum waiting time. Questions such as how many depots, how many buses in each depot, etc. will be studied.

Personnel Requirements

First Year

Senior Staff (K. S. P. Kumar)
1/4 time, 9 months
full time, 2 months

Student Assistants (One graduate assistant)
1/2 time, 9 months
full time, 3 months

Second and Third Year requirements are the same.

Time Schedule of Project

Essentially the program for each year will be adhered to.

Plans for Publication

The findings will be documented in University reports. Pertinent results of general interest will be published in professional periodicals.

Faculty Biography

K. S. P. Kumar, Ph.D., Associate Professor of Electrical Engineering.

Statement of Travel

In order to understand and communicate our efforts with others, travel funds are needed to attend symposia, professional society meetings and occasional visits to other universities engaged in similar research work.

Project Geog 1: FORECASTING AREAL DEMAND FOR SUBURBAN MASS TRANSPORTATION FACILITIES IN THE TWIN CITIES METROPOLITAN AREA (TCMA)

Objectives

1) To provide small-area estimates of population, employment, vehicle ownership, and other traffic-generating characteristics along existing and projected corridors of high-volume usage in the suburban TCMA;

2) To estimate travel demand in each area for the year 1985 (or specified other target dates) with sub-sets of demand for travel along the defined corridors into the central cities;

3) To generate, by variable modal splits, the amount of traffic which might be expected to utilize transit services on freeways and major arterials (bus), new and existing rail lines, and future innovations (mono-rail, e.g.).

The overall aim is to develop a general method of providing traffic input for model testing and simulation of mass transit feasibility. Related research proposals will be integrated via cooperative effort to specify "working parameters," such as types of facilities, spacing of interchanges and stations, and modal shares, based upon experiences in other urban areas. In addition, the training and educational aspect will be promoted by the inclusion of graduate students as project personnel; also, it is anticipated that trainees will take designated courses and participate in joint seminars in furtherance of their graduate program.

Phases

This project is planned to be carried out in three stages, each stage covering an academic year, as follows:

I. First-Year: Data Collection and Processing.

1. Identification of the areas and corridors of high-traffic volumes at present and to the projected date (1985); these "problem" and "potential" zones

will be based largely upon materials of the Minnesota Highway Department from the Twin Cities Area Transportation Study and continuing research.

2. Division of the suburban TCMA into data-collection units (probably traffic assignment zones and aggregates of them).

3. Applying generalized forecasts of the Metropolitan Council and State Planning Agency of residential, commerical and industrial growth to the sub-areas. This task will involve greater specificity than presently available in given areas; hence, field trips and discussion in the local communities will be necessary.

4. Applying established and expected land use traffic generation rates and volume distributions (for peak hour demand) to estimate sub-area needs.

5. Computer processing by the University 6600 and 3200 (CDC) centers to output local area travel demand by origin and destination areas.

Note: The First-Year phase will be primarily devoted to mapping, data coding and computer runs to develop input for Phase II.

II. Second-Year: System Testing. (Details to be worked out later.)

1. Under various assumptions of types of facilities and station spacing, by specification from related projects, the estimated future traffic will be "loaded" to determine probable use volumes. Proportions of future traffic expected to use mass transit between nodes will be generated.

2. Field interviewing. It is believed that small-sample household interviewing will be valuable information to estimate "real" versus probable transit usage. Also, estimates and data from other urban areas with comparable characteristics will be introduced for refinement. A number of metropolitan areas in the U.S., San Francisco, Chicago, etc., have begun suburban mass transit under constricted and low-density conditions. Contact with them and the Bureau of Public Roads Planning Division will be important linkages.

III. Third-Year: System Evaluation, Reports and Recommendations

1. Further system testing based upon additional information and concurrent results, are probable.

2. Generation of estimating equations for any area are expected.

3. Coordinated with other projects, reports and recommendations will be prepared to evaluate usage, costs, revenues and overall feasibility, with a suggested order of priority.

4. Results are expected to be of integral value for a Transportation/Land Use Plan in conjunction with the Minnesota Highway Department, State Planning Agency, and Metropolitan Council.

Publication of Results

The results of the research will be published initially as a technical report of the Center for Urban and Regional Affairs. Thereafter, one or more papers will be prepared for technical journals, as appropriate.

Project ME 1: A STUDY OF THE DYNAMICS OF INTERACTION POINTS COUPLING TRANSPORTATION MODES

Objectives of the Project

The development of efficient modes of mass transportation relies heavily on a set of design criteria which state desired performance properties for the system. Conceptually, the criteria for a systems study of this order are numerous, and include such features as traverse time, flexibility, reliability, economy, consumer acceptance and comfort. Without a clear statement of criteria, trade-off studies are impossible to perform as there is no way to establish how well the design fits within acceptable bounds on performance. Of course, these criteria may be difficult to state, as they often include social and psychological responses which are not always amenable to quantification. However, criteria can often be established by assumption, and the sensitivity of the design to those assumptions can subsequently be established.

The development of design criteria for the interaction between future transportation modes and existing systems (highways, bus systems, pedestrian routes) appears to be essential to realize the full potential of a mass transportation mode. An understanding of such interactive effects would provide a basis for establishing strategy within the system.

This proposal presents a stepped effort to evolve interaction criteria between transportation modes. The study would include inputs from staff with skills in the social and behavioral sciences to provide a basis for stating criteria involving human response during the second and third years' effort.

Specific Problem Statement

First Year Study

The initial study would be directed toward an evaluation of traverse time, or "friction factor"* through an interaction point between modes as depicted below.

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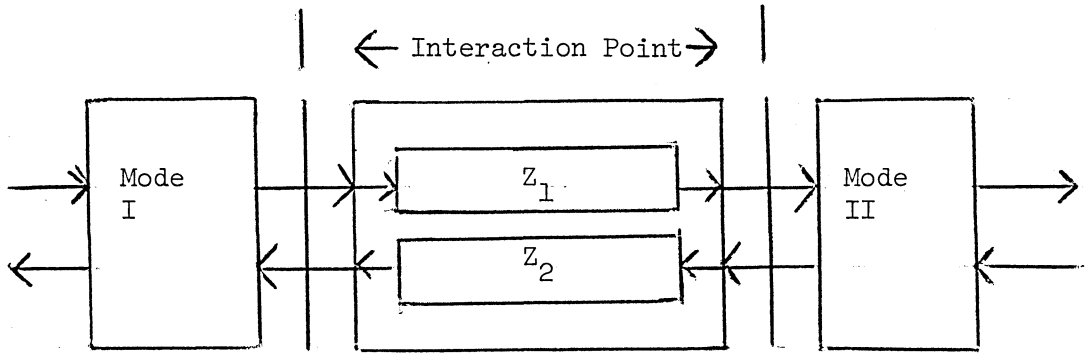
*Traffic Assignment Manual, Bureau of Public Roads, Office of Planning, Urban Planning Division, June 1964.



The study would evaluate the traverse time through the system by regarding the design characteristics of the interaction as generators of a series sequence of time delays. Modes I and II would be regarded as analagous to infinite sources and sinks, with a steady state flow of traffic in each. The modes would be uncoupled from the standpoint of traffic rate in each, which is a way of saying that at this stage in the study, density and velocity would be regarded as independent within each mode. The coupling between modes would be from a user standpoint only, in that delay time would be incurred between two systems operating in steady state. Types of traffic flow in each mode would be included. For example, Mode I might represent a bus system operating on a fixed schedule using traditional equipment, interacting with a mass transportation system of small multi-passenger vehicles such as the Starr-Car, again operating with a defined strategy (Mode II). Obviously, traffic density and velocity are interrelated within the interaction point, as time delays are a function of configuration and density.

This study would provide an indicationoof traverse time (T) between input and output points based on the impedance (Z) of the interaction and a set of defined strategies (S) within Modes I and II:

$$T = f(Z, S_I, S_{II}).$$

$$\text{where } S_I \neq f(S_{II}).$$

Model and queuing theory, and mathematical techniques of dynamical systems analysis and perturbation theory appear to be particularly valuable in this context.

This phase would not explicitly include human strategy charges incurred by traffic delays (for instance, a decision to return to a given mode because of excess density). However, delay times incurred by debarkation and embarkation of individual users would be included based on existing data or simple experiment.

The information provided by this initial study would suggest design studies of interaction points to accommodate peak loads and facilitate ease of traverse, as well as to provide a base for an economic analysis of interaction stations and their locations. A parallel simulation study of the basic transportation modes, their strategies and responses to load variations would couple with the information from this interaction study to establish under what conditions the assumptions concerning modal uncoupling are valid.

Second Year Study

This effort would be regarded as a refinement of the first year's study in the following respects:

Various loading and unloading strategies would be studied to determine their effect on traverse time. Several Mass transportation systems have been proposed with provision for series loading of vehicles. At this point, it appears uncertain that this strategy is wise, as it is very dependent on the destination objectives, queue size, and vehicle availability at the loading site. The implication of loading strategy on the interaction as well as the basic transportation modes should be understood, as it may be a governing factor in establishing the physical properties (flexibility, etc.) of the participating transportation modes.

Consultation with behavioral sciences personnel would provide a basis for judging the effect of human response on traffic density and traverse time within interaction points. For example, excessive waiting times could generate flow back into a given transportation mode, as decisions are made to return to the original destination or to use alternate routes.

An evaluation of existing mass transportation system designs from the standpoint of their adaptability to interaction strategies.

Third Year Study

Interaction point studies would be coupled with parallel simulation studies of major transportation modes to determine the validity of assumptions concerning modal uncoupling, and to predict the effect of interaction delays on the response of major transportation modes. For example, queue size and strategy within a mode interact, and require a trade-off between traverse time past the interaction with queue size at the interaction. Simulation studies of a particular mode, with sufficient versatility to accept various strategies will couple with the first two years' interaction studies to permit an understanding of these trade-offs.

Personnel Requirements

First Year

Senior Staff (Darrell A. Frohrib, Principal Investigator)
1/4 time, 9 months
1/2 time, 2 months

Research Assistants
1/2 time, 9 months
full time, 2 months

Second Year

Senior Staff (Darrell A. Frohrib)
1/4 time, 9 months
1/2 time, 2 months

Research Assistants
Two, 1/2 time, 9 months
Two, full time, 3 months

Third Year

Senior Staff
Two, 1/4 time, 9 months
Two, 1/2 time, 3 months

Research Assistants
Three, 1/2 time, 9 months
Three, full time, 3 months

Project ME 2: OPERATIONAL CHARACTERISTICS OF MASS TRANSIT SYSTEMS

Objectives of the Project

New approaches to the problem of urban mass transit such as carveyor, skybus, starrcar, teletrans, uniflo, urbmobile have been under development in recent years. By taking advantage of modern technology in various ways, these systems appear to offer the hope of finding truly effective means for solving urban problems of congestion and movement. These systems appear viable now to a great extent because of the possibility of digital control of functions beyond human capacity, and, because of the resultant complexity, can be studied in realistic detail only by computer simulation.

The objectives of this project are (1) to analyze operational characteristics of various types of transit systems in specific circumstances in order to determine optimum specifications for each candidate system, to determine the sensitivity of the characteristic system parameters to various changes, to uncover operational problems in specific systems, to rate the various candidate systems operationally; (2) to study digital-computer control of the system; (3) to provide operational data essential for economic, architectural, mode-transfer, sociological and other studies; and (4) to further develop and expand the digital simulation as a fundamental tool for analysis of transit systems, a tool which any institute engaged effectively in research and training in modern mass transit must have in house.

Problems to be Investigated

The problem to be investigated in the first year is an intracampus transit system for the Twin Cities Campus of the University of Minnesota. An urgent need for such a system has been documented by the University Committee on Parking and Circulation (ref. 1) and it is currently being considered for a demonstration run by the Twin Cities Metropolitan Transit Commission. Routes for this system have been proposed and detailed estimates of the growth of the University population to the year 1980 have been made. Thus, the basic data needed

for the proposed study is available. These studies show a projected university population in 1980 of over 80,000, and also that continuation of present trends leading to the need for more and more parking space is not a viable solution. The Twin Cities Campus is divided into two distinct parts; the main campus in Minneapolis, now extended to the West Bank of the Mississippi River; and the St. Paul Campus, three miles away, which is smaller, but has a great deal more space adjacent to it and available for growth. A joint transit link will unite these parts realistically into a single Twin Cities campus in which students will have freedom of choice of courses in various corners of the Campus. The transit system will, on a small scale, have most of the features of a metropolitan system; Transit between centers of concentration, rush hours, interfaces with alternate modes, interconnecting links.

In the second and third years of this project it is intended that we will continue the investigation of the intracampus system, but plan also to take up successively--

> The problem of a mass transit system between Wayzata, Minnesota and the Minneapolis CBD. Preliminary studies of such a route have been made at Rosemount Engineering Company in connection with the Uniflo system and the availability of a computer simulation will be helpful to that work. (See attached letter)
>
> The problem of a NET system such as described by Stanford Research Institute for a section of the Twin Cities Metropolitan area. This study would take advantage of the work already done by SRI (ref. 2).

Methods to be Used

The basic tool of this project will be an operational simulation on the University of Minnesota CDC 6600 Computing System. In this simulation, the fixed features of the transit system such as the track and stations will be stored in the computer memory. Positions of the vehicles will be updated at discrete time intervals taking into account propulsive and braking forces, and the effects of grades, curves and other disturbances such as the proximity of adjacent vehicles.

The important inputs to the simulation will be the rates at which riders will approach the stations when classes are dismissed and the time required for individuals to pass through the

station and situate themselves in the vehicles. Approximate describing functions for these rates will be obtained from studies done in companion projects. It is recognized that the prediction of these describing functions for situations far in the future in which the transit system is an established mode of transportation is the most difficult and basic task of transit system analysis.

Many computer simulations have been developed for the study of transit systems. Therefore, the emphasis here need be only on the adaptation of these simulations to specific purposes, just as one would adapt any analysis tool to his own needs. The Twin Cities Metropolitan Transit Commission has offered to make simulations done for them available to us, and the Control Data Corporation, similarly, has cooperated in allowing us to become familiar with simulations developed in their Urban Affairs section. In addition, we will review the literature available on digital simulations, and, when necessary, visit other institutes to become familiar with their methods. The extensive experience of the principal investigator in computer programming will be fully utilized in absorbing and adapting existing simulations and in training others in their use.

Data to be Collected

Data of the following types will be obtained:

System capacity (people per hour) under peak conditions

Overall transit time from entrance to one station to exit from another

Waiting times

Speeds and spacing of vehicles at various locations along the track

The maximum acceleration and jerk of the vehicle

The rate of egress from each station under peak conditions

These data will be collected as function of variables such as:

The running speed between stations

The total number of vehicles in the system at peak loading

The number of passengers spaces per vehicle

The number and location of stations

The station delay time

Type of Results to be Expected

It will be realistic to expect the following type of results from the proposed simulation:

The peak capacity of a given system (can it do the job?)

Optimization of parameters such as running speed, total number of vehicles, spaces per vehicle, loading berths per station, number and spacing of stations, and the sensitivities of these variables to various changes

Isolation and solution of problems of computer control of a given system

Performance specifications for component parts

The safe minimum vehicle spacing

Variation of the rate of change of maximum system capacity with the time a rider must wait to board the system under extreme conditions. This data will enable the optimum maximum system capacity to be determined taking into account economic and psycological factors

Typical maximum egress rates from each station and other data which will allow one to study problems of coupling of the transit system with alternate modes.

Identification of particular candidate transit systems capable of fulfilling operational requirements

An intangible result will be that, because the simulation will enable the investigator to think deeply and realistically about the details of operational problems, transit systems built from computer-determined specifications will be close to optimum and relatively trouble free. This will have a considerable impact on total development costs.

The data obtained will provide essential background for cooperative investigations in other field and for cognizant authorities to explain system operational features to legislators, local city councils, potential users, etc.

The simulation will be an important factor in determination of criteria for acceptability of transit systems.

Personnel Requirements

First Year

Senior Staff

J. E. Anderson
1/4 time, 9 months
1/2 time, 3 months

Student Assistants

Two Research Assistants
1/2 time, 9 months
full time, 3 months

One Undergraduate Student
1/2 time, 9 months
full time, 3 months

References

1. Report of the Ad Hoc Committee on Circulation and Parking to the President of the University of Minnesota, September 1967.
2. Future Urban Transportation Systems, Final Reports I and II, Stanford Research Institute, March 1968.

Second Year

Senior Staff

J. E. Anderson
1/4 time, 9 months
1/2 time, 3 months

New appointment
1/4 time, 9 months
1/2 time, 3 months

Student Assistants

Three Research Assistants
1/2 time, 9 months
full time, 3 months

Two undergraduate students
1/2 time, 9 months
full time, 3 months

Third Year

Senior Staff

J. E. Anderson
1/4 time, 9 months
1/4 time, 3 months

New appointment
1/4 time, 9 months
1/2 time, 3 months

Student Assistants

Four Research Assistants
1/2 time, 9 months
full time, 3 months

Undergraduate students
1/2 time, 9 months
full time, 3 months

Time Schedule of the Project

We have already begun reviewing simulations and gathering data for the intracampus simulation, and will continue to do so with time available until the project formally begins. It is expected that our first simulation program will be operational in several months. Following this, we will begin with fairly simple runs to gain familiarity with the program and to introduce necessary refinements, and will gradually introduce a greater and greater amount of realism into the program as data becomes available on input functions. Within a few months after initiation of the project, we should be obtaining useful results.

Project ME 3: ENGINEERING PROBLEMS IN URBAN MASS TRANSIT SYSTEMS

Objectives of the Project

To develop solutions to specific engineering problems in connection with new types of transit systems.

Problems to be Investigated

The problems to be investigated will be chosen based on their suitability for graduate student projects with the advice of the Metropolitan Transit Commission and the University Committee on Parking and Circulation. They may rise from discussions with these people and/or their consultants, from discussion with the several local industries engaged in Urban Transportation and/or from computer-simulation studies. Strong emphasis will be placed on problems which can be investigated jointly with people in other fields. Representative types of problems which may be investigated are:

Trip demand models

Simplified describing functions to use until more complete functions become available

Computer control of transit systems

Mechanical problems of propulsion and suspension

Mechanical design of stations, fare collection methods

Methods to be Used

Methods will, of course, vary with the problems. The problems will be under the direction of a principal investigator who has had a wide range of experience in engineering problem solution in the aero-space industry. Full advantage will be taken of related work; computer simulations and/or experiments will be set up where needed.

Type of Results to be Expected

The aim in this project will be to obtain results which will solve important specific problems and at the same time will indicate how to handle general classes of problems.

Personnel Requirements

First Year

Senior Staff
J. E. Anderson
1/4 time, 9 months
1/2 time, 2 months

Student Assistants
One Research Assistant
1/2 time, 9 months
full time, 3 months

Secretary, 1/4 time

Second and Third Years

Senior Staff
J. E. Anderson
1/4 time, 9 months
1/2 time, 3 months

New appointment,
1/4 time, 9 months
1/2 time, 2 months

Student Assistants
Two Research Assistants
1/2 time, 9 months
1/4 time, 3 months

Secretary, 1/4 time

Publication of Research Findings

The findings of each research project will be completely documented in a research report to be issued by CURA. In addition, authors will be encouraged to prepare papers for publication in appropriate professional journals.

V. RELATIONSHIPS WITH LOCAL GOVERNMENTAL AGENCIES

Past Activities

For many years various departments of the University have carried out research projects for the Minnesota Highway Department. Notable among these have been the series of Highway Impact Studies conducted jointly by land economists and economic geographers and the engineering and design studies by research teams at the Experimental Engineering laboratories. Both projects have involved students, faculty and highway personnel working in close association and have had important training dimensions. Also, for more than a decade the School of Public Affairs and Highway Department have had a cooperative program of training internships. Interns have been placed mainly in the Planning and Research field.

Present and Future Activities

In order to explore another research project related to urban transportation, an advisory committee has been previously formed consisting of the following agencies:

University of Minnesota
- Department of Civil Engineering
- Department of Economics
- Department of Geography

Minnesota Highway Department

Metropolitan Council

Metropolitan Transit Commission

State Planning Agency

U.S. Bureau of Public Roads (District Office)

We have reason to believe that all of these agencies plus some additional agencies, as well as certain private industries, will cooperate with the proposed program of training and research.

BUDGET SUMMARY

Budget Items	1969-70 U of M Contribution	1969-70 Proposed Sponsorship	1970-71 U of M Contribution	1970-71 Proposed Sponsorship	1971-72 U of M Contribution	1971-72 Proposed Sponsorship
Training Program		211,986		300,635		216,082
Research Program						
CE 1	6,544	16,823	7,195	17,375	7,911	19,027
Econ 1,2,3		9,161				
Econ 4	7,669	20,646	8,118	28,622		14,711
EE 1	5,378	15,240	5,913	13,269	6,527	14,249
Geog 1	5,378	12,056	6,142	6,206	6,525	6,676
ME 1	5,305	11,679	5,827	19,846	11,521	32,057
ME 2	5,759	15,503	6,330	31,283	6,963	45,711
ME 3	5,759	9,946	6,332	15,927	6,963	26,268
TOTALS	41,792	323,040	45,857	433,163	46,410	374,781

PROJECT TOTAL = $1,265,043

U OF M CONTRIBUTION = $134,059

PROPOSED SPONSORSHIP = $1,130,984

PROGRAM IN URBAN TRANSPORTATION -- TRAINING PROGRAM

Training Program Coordination	1969-70 Proposed Sponsorship	1970-71 Proposed Sponsorship	1971-72 Proposed Sponsorship
Program Coordinator (1/2 time 9 mos, full time 2 mos.)	15,490	17,040	18,744
Administrative Assistant (1/2 time 9 mos., full time 3 mos.)	4,840	5,324	5,856
Secretary (12 mos)	4,272	4,440	4,624
Secretary (1/2 time)		2,220	2,312
Fringe benefits	1,968	2,344	2,542
Health $13/man mo.	240	318	318
Materials and supplies	500	500	500
Printing and publicity	1,000	2,000	2,000
Travel	1,000	760	760
(Detailed Breakdown)			
San Francisco/Berkeley			
($210 ticket + 2 days per diem @ $25 day)	1 trip (260)		
Washington, D.C.			
($100 ticket + 2 days per diem @ $25/day)	2 trips (300)	3 trips (450)	3 trips (450)
Pittsburgh			
($90 ticket + 2 days per diem @ $25/day)	1 trip (140)	1 trip (140)	1 trip (140)
New York			
($120 ticket + 2 days per diem @ $25/day)		1 trip (170)	1 trip (170)
College Station, Texas			
($162 ticket + 2 days per diem @ $25/day)	1 trip (212)		
Miscellaneous travel	(88)		
	(29,310)	(34,946)	(37,656)

Training Grants	111,135	176,814	111,135
Cost of Education* (@ $2500/trainee)	37,500	60,000	37,500
Seminar Series			
Visual Aids	500	500	500
Honoraria	2,500	2,500	2,500
Experimental Training in:			
Mass Transportation System Design in Mechanical Engineering			
Current Faculty			
J.E. Anderson (1/4 time 9 mos)	7,200	7,920	8,712
D.A. Frohrib			
New Faculty #1 (1/4 time 9 mos)		3,025	3,328
New Faculty #2			3,328
Secretary (1/4 time)	1,068	1,110	1,155
Fringe Benefits	832	1,217	1,673
Health	98	127	156
Supplies	125	200	300
Travel	500	500	625
Computer expense	400	600	900
Indirect costs (8% of direct costs)	818	1,176	1,614
	(11,041)	(15,875)	(21,791)
Unallocated Fund**	20,000	10,000	5,000
Short Course Series***	------	------	------
TOTALS	$211,986	$300,635	$216,082

*This allowance amounts to $2500 per trainee and includes the "tuition and fee" portion of the grant to the student and indirect costs.

**Unallocated funds are to assist with course development as needs become evident in various departments. Also, they serve in lieu of new appointees during first year.

***It is proposed that the short course series will be self-supporting. Deficits, if any, will be made up by the Center for Urban and Regional Affairs.

CE 1 RESEARCH BUDGET

Budget Items	1969-70 U of M Contribution	1969-70 Proposed Sponsorship	1970-71 U of M Contribution	1970-71 Proposed Sponsorship	1971-72 U of M Contribution	1971-72 Proposed Sponsorship
Senior Staff (M. J. Huber) (1/4 time 9 mos, full time 2 mos)	4,263	3,789	4,689	4,168	5,158	4,585
Research Assistant (1/2 time 9 mos, full time 3 mos)		4,840		5,324		5,856
Secretary (1/8 time)		534		555		578
Fringe Benefits	435	435	478	476	526	520
Health	30	72	30	72	30	72
Overhead	1,816	3,903	1,998	4,280	2,197	4,694
Data collection & Travel*		2,000		1,000		522
Materials and Supplies		500		500		200
Computer expense (@ $17/minute 6600 CDC)		750		1,000		1,500
Publication costs						500
TOTALS	6,544	16,823	7,195	17,375	7,911	19,027

PROJECT TOTAL = $74,875

U OF M CONTRIBUTION = $21,650

PROPOSED SPONSORSHIP = $53,225

*1969-70 travel: $225 for trip to Washington, D.C. ($100 ticket + $25 per diem for five days)
$317 for trip to Los Angeles for Institute of Traffic Engineers Conference ($192 ticket + $25 per diem costs)
$1458 for travel by senior staff and research assistant in-state, including overnight and one-site data collection.

1970-71 travel: $225 for trip to Washington, D.C.
$265 for trip to Houston for Institute of Traffic Engineers Conference
$510 for in-state travel for data collection

1971-72 travel: $225 for trip to Washington, D.C.
$297 for trip to Montreal for Institute of Traffic Engineers Conference

ECON 1, 2, 3 RESEARCH BUDGET

1969-70

Dept. #		U of M Contribution	Proposed Sponsorship
Econ 1) Econ 2) Econ 3)			
	Senior Staff (H. Mohring) 1 mo. summer		1,800
	Two Research Assistants (Summer)		3,528
	Computational Assistance (400 hrs. @ $1.90/hr.)		760
	Secretarial Services (120 hrs. @ $1.65/hr.)		198
	Fringe Benefits		197
	Overhead		2,678
		PROJECT TOTAL =	$9,161

CE 1 RESEARCH BUDGET

Budget Items	1969-70 U of M Contribution	1969-70 Proposed Sponsorship	1970-71 U of M Contribution	1970-71 Proposed Sponsorship	1971-72 U of M Contribution	1971-72 Proposed Sponsorship
Senior Staff (M. J. Huber) (1/4 time 9 mos, full time 2 mos)	4,263	3,789	4,689	4,168	5,158	4,585
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Fringe Benefits	435	435	478	476	526	520
Health	30	72	30	72	30	72
Overhead	1,816	3,903	1,998	4,280	2,197	4,694
Data collection & Travel*		2,000		1,000		522
Materials and Supplies		500		500		200
Computer expense (@ $17/minute 6600 CDC)		750		1,000		1,500
Publication costs						500
TOTALS	6,544	16,823	7,195	17,375	7,911	19,027

PROJECT TOTAL = $74,875

U OF M CONTRIBUTION = $21,650

PROPOSED SPONSORSHIP = $53,225

*1969-70 travel: $225 for trip to Washington, D.C. ($100 ticket + $25 per diem for five days)
$317 for trip to Los Angeles for Institute of Traffic Engineers Conference ($192 ticket + $25 per diem costs)
$1458 for travel by senior staff and research assistant in-state, including overnight and one-site data collection.

1970-71 travel: $225 for trip to Washington, D.C.
$265 for trip to Houston for Institute of Traffic Engineers Conference
$510 for in-state travel for data collection

1971-72 travel: $225 for trip to Washington, D.C.
$297 for trip to Montreal for Institute of Traffic Engineers Conference

ECON 1, 2, 3 RESEARCH BUDGET

1969-70

Dept. #		U of M Contribution	Proposed Sponsorship
Econ 1) Econ 2) Econ 3)			
	Senior Staff (H. Mohring) 1 mo. summer		1,800
	Two Research Assistants (Summer)		3,528
	Computational Assistance (400 hrs. @ $1.90/hr.)		760
	Secretarial Services (120 hrs. @ $1.65/hr.)		198
	Fringe Benefits		197
	Overhead		2,678
		PROJECT TOTAL =	$9,161

ECON 4 RESEARCH BUDGET

Budget Items	Contribution	Sponsorship	Contribution	Sponsorship	Contribution	Sponsorship
Senior Staff(H. Mohring)						
1/2 time 9 mos 1969-70, 70-71	5,000	5,000	5,300	5,300		
2 mos full time summer 1970		1,800		4,500		4,750
Two Research Assistants						
1 - 1/2 time summer 1969		715				
2 - 1/2 time 9 mos, 69-70, 70-71		4,300		4,700		
2 - 3/4 time 3 mos summer 70 & 71				2,360		2,590
Senior Secretary (1/4 time 10 mos)		1,000		1,320		1,450
Fringe Benefits	510	784	531	1,109		617
Health plan	29	88	29	88		59
Overhead	2,130	5,459	2,258	7,745		3,745
Computer time		1,500		1,500		1,500
TOTALS	7,669	20,646	8,118	28,622		14,711

PROJECT TOTAL = $79,766

U OF M CONTRIBUTION = $15,787

PROPOSED SPONSORSHIP = $63,979

EE 1 RESEARCH BUDGET

Budget Items	1969-70 U of M Contribution	1969-70 Proposed Sponsorship	1970-71 U of M Contribution	1970-71 Proposed Sponsorship	1971-72 U of M Contribution	1971-72 Proposed Sponsorship
Senior Staff(K. S. P. Kumar) 1/4 time 9 mos, full time 2 mos.(summer)	3,500	3,000	3,850	3,300	4,250	3,630
Research Assistant						
1/2 time 9 mos		3,000		3,300		3,630
Full time summer		2,000				
Fringe benefits	357	306	393	331	436	370
Health	30	26	30	26	30	26
Overhead	1,491	3,408	1,640	2,812	1,811	3,093
Supplies		500		500		500
Travel		1,000		1,000		1,000
Computer expense (@ $17/minute 6600 CDC)		2,000		2,000		2,000
TOTALS	5,378	15,240	5,913	13,269	6,527	14,249

PROJECT TOTAL = $60,576

U OF M CONTRIBUTION = $17,818

PROPOSED SPONSORSHIP = $42,758

GEOG 1 RESEARCH BUDGET

Budget Items	1969-70 U of M Contribution	1969-70 Proposed Sponsorship	1970-71 U of M Contribution	1970-71 Proposed Sponsorship	1971-72 U of M Contribution	1971-72 Proposed Sponsorship
Senior Staff(R. B. Adams) (1/4 time, 9 mos)	3,500		4,000		4,250	
Research Assistant (1/2 time 9 mos)		3,000		3,300		3,630
Research Assistant (1/2 time 9 mos)		3,000				
Fringe Benefits	357		408		434	
Health Plan	30		30		30	
Overhead	1,491	2,556	1,704	1,406	1,811	1,546
Materials		1,500				
Travel		1,000		750		
Trips to Washington, D.C.		(300)		(300)		
Local Travel		(700)		(450)		
Computer expense (@ $17/minute 6600 CDC)		1,000		750		500
Report preparation						1,000
TOTALS	5,378	12,056	6,142	6,206	6,525	6,676

PROJECT TOTAL = $42,983

U OF M CONTRIBUTION = $18,045

PROPOSED SPONSORSHIP = $24,938

ME 1 RESEARCH BUDGET

Budget Items	1969-70 U of M Contribution	1969-70 Proposed Sponsorship	1970-71 U of M Contribution	1970-71 Proposed Sponsorship	1971-72 U of M Contribution	1971-72 Proposed Sponsorship
Senior Staff						
1/4 time 9 mos, 1/2 time 2 mos						
D. A. Frohrib	3,450	1,533	3,794	1,686	4,174	1,855
New Position					3,328	1,479
Research Assistants						
1/2 time 9 mos, full time 3 mos						
1 First Year		4,410				
2 Second Year				9,702		
3 Third Year						16,008
Secretary (1/4 time)		1,068		1,110		1,150
Supplies		125		200		300
Travel		500		500		625
Computer expense		700		1,000		1,400
Fringe Benefits	356	254	387	273	765	445
Health plan	29	52	29	52	58	65
Overhaed	1,470	2,987	1,617	5,323	3,196	8,730
TOTALS	5,305	11,679	5,827	19,846	11,521	32,057

PROJECT TOTAL =$86,235

U OF M CONTRIBUTION = $22,653

PROPOSED SPONSORSHIP = $63,582

ME 2 RESEARCH BUDGET

Budget Items	1969-70 U of M Contribution	1969-70 Proposed Sponsorship	1970-71 U of M Contribution	1970-71 Proposed Sponsorship	1971-72 U of M Contribution	1971-72 Proposed Sponsorship
Senior Staff						
1/4 time 9 mos, 1/2 time 2 mos						
J. E. Anderson	3,750	1,667	4,124	1,833	4,538	2,017
New Position				4,369		4,806
Research Assistants						
1/2 time 9 mos, full time 3 mos						
1 First Year		4,410				
2 Second Year				9,702		
3 Third Year						16,008
Undergraduate Assistants						
1/4 time 9 mos, full time 3 mos						
1 First Year		1,592				
1 Second Year				1,751		
2 Third Year						3,852
Secretary (1/4 time)		1,068		1,110		1,150
Fringe Benefits	382	267	420	734	463	801
Health plan	29	52	29	95	29	95
Overhead	1,598	3,722	1,757	7,994	1,933	11,857
Supplies		125		200		300
Travel		500		500		625
Computer expense		2,100		3,000		4,200
TOTALS	5,759	15,503	6,330	31,283	6,963	45,711

PROJECT TOTAL = $111,549

U OF M CONTRIBUTION = $19,052

PROPOSED SPONSORSHIP = $92,497

ME 3 RESEARCH BUDGET

Budget Items	1969-70 U of M Contribution	1969-70 Proposed Sponsorship	1970-71 U of M Contribution	1970-71 Proposed Sponsorship	1971-72 U of M Contribution	1971-72 Proposed Sponsorship
Senior Staff						
J. E. Anderson	3,750	1,667	4,125	1,833	4,538	2,017
New Position 1/4 tim 9 mos, 1/2 time 2 mos						4,806
Research Assistants 1/4 time 9 mos, full time 3 mos						
1 First Year		3,087				
2 Second Year				6,792		
3 Third Year						8,208
Secretary (1/4 time)		1,068		1,110		1,150
Fringe Benefits	382	267	421	293	463	801
Health plan	29	52	29	52	29	68
Overhead	1,598	2,480	1,757	4,147	1,933	6,893
Supplies		125		200		300
Travel		500		500		625
Computer expense		700		1,000		1,400
TOTALS	5,759	9,946	6,332	15,927	6,963	26,268

PROJECT TOTAL = $71,195

U OF M CONTRIBUTION = $19,054

PROPOSED SPONSORSHIP = $52,141

APPENDIX A

FACULTY RESUMES

Russell B. Adams

Date of Birth: January 1, 1926

Education: B.B.A. University of Minnesota, 1949 (Economics)
B.S. (Education) University of Minnesota, 1952
M.A. (Geography) University of Minnesota, 1955
Ph.D. (due June 1968) University of Minnesota; Geography major, Statistics, minor

Professional Experience:

1952-1953	High School Teaching (Math and Business), Hill City, Minnesota
1953-1957	Graduate Teaching Assistant and Lecturer (Geography and Social Science), University of Minnesota
1957	Observer, U.S. Government (CIA)
1957-1958	Program-Planner, Remington-Rand Univac, St. Paul
1958-1961	Ass't. Director, Twin Cities Area Transportation Study, Minnesota Highway Department
1961-1963	Ass't. Director, Urban Research Program, Upper Midwest Economic Study, Mpls.-St. Paul
1964-Present	Instructor and Ass't. Professor, Geography Department, University of Minnesota

Selected Publications:

"Work Program, 1960" TCATS, Minnesota Highway Department, 1960, St. Paul.

Manuals for TCATS Travel Survey, Minnesota Highway Department, 1959-61, St. Paul
a) Internal Home Interview
b) Truck/Taxi Survey
c) Coding-Data Processing Manual.

"A-F Tables," (Travel Survey), TCATS Report No. 19, Minnesota Highway Department, 1961, St. Paul.

"A Test of the Schneider (Opportunity) Model," TCATS Report No. 25, Minnesota Highway Department, St. Paul, March 1961, (with L. Wroblewski).

Trade Centers and Trade Areas of the Upper Midwest, Urban Research Program Report No. 3, Upper Midwest Economic Study, Minneapolis, 1963 (with J. Borchert).

Population Mobility in the Upper Midwest, Urban Research Program Report No. 6, Upper Midwest Economic Study, Minneapolis, 1964.

Projected Urban Growth in the Upper Midwest, 1960-1975, Urban Research Program Report No. 8, Upper Midwest Economic Study, Mpls., 1964 (with J. Borchert).

"Geographic Training and Urban Planning," Professional Geographer, May 1967 (with E. Maranda).

"Soviet Envoy Tells 'U' Prof of Peking Chaos," article in Minneapolis Tribune (Editorial Page), Dec. 30, 1967.

"Review of I. Lowry's 'Migration and Metropolitan Growth; two analytical models,'" Journal of Regional Science, Winter 1968.

"Recent Trends and Prospects in Water-Borne Commerce in the Twin Cities Area," Papers of the First Annual Water Transport Commerce, State Planning Agency, St. Paul, 1968.

"Social and Economic Profile," Chap. 3 in: St. Anthony Park Plan, St. Anthony Park Planning Commission, St. Paul, 1968.

"USSR Transportation," Focus (American Geographical Society, New York), 1968 (forthcoming, summer 1968).

"Migration Geography: A Methodological Inquiry and Case Study," Ph. D. thesis (forthcoming, June 1968), University of Minnesota, Department of Geography, Minneapolis.

JOHN EDWARD ANDERSON
Associate Professor of Mechanical Engineering
University of Minnesota

Formal Education

BSME	Iowa State College, 1949
MSME	University of Minnesota, 1955
Ph.D.	M.I.T. Department of Aeronautics and Astronautics, 1962

Professional Experience

1949-1951 Aeronautical Research Scientist, NACA, Langley Field, Va. Developed methods of analysis of stresses and deflections in delta wings. Experience with high-speed electronic computation. NACA Report 1131, 1953.

1951-1959 Honeywell, Inc., Aeronautical Division

1951-1954 Development Engineer, Work Director. Developed and designed components of aircraft fuel measurement systems, U.S. Patents 2,2824,270; 2,916,679. Product-of-the-month Award, Aviation Age, May, 1953.

1954-1955 Senior Research Engineer. Analysis and synthesis of military aircraft autopilot systems via analog computer and other techniques.

1955-1956 Research Project Engineer, Technical director of analytical work on F100 and F107 autopilot systems, U.S. Patent 2,944,203.

1956-1957 Research Project Engineer, Inertial Guidance. Invented and led development of gimballess inertial system, and novel ballistic missle guidance system. U.S. Patent 3,011,350.

1957-1958 Principal Research Engineer. Consultant on inertial navigation, control, dynamics and vibration engineering, led proposed efforts, lectured on inertial navigation to customers in government and industry, directed project to develop master reference system for Polaris submarine which led to major contract.

1958-1959 Research Staff Engineer. Proposal work, led large department-wide program for development of gimballess inertial system which led to contract.

1959-1962 M.I.T. Fellow in Aeronautics and Astronautics. Ph.D. Thesis: "Magnetohydrodynamic Shock Waves," M.I.T. Press, 1963.

1962-1963 Staff Consultant, Manager of Space Systems. Staff studies on laser effects, high-power laser, magneto-hydrodynamic ststems. Technical Director of large preliminary design study of Solar Probe Spacecraft which led to first corporate space-systems contract.

1963-present Associate Professor, Mechanical Engineering Department

1963-1967 Taught magnetohydrodynamics, thermodynamics, heat transfer, design. Research in magnetogasdynamics of electric arcs involving numerical solution of partial differential equations CDC 1604, 6600. Consultant to industry in spacecraft systems, explosion dynamics, magneto- and electrohydrodynamics, inertial systems.

1967-1968 National Academy of Sciences Exchange Professor in the Soviet Union

1968-present Major portion of research time devoted to latent interests in urban mass transit systems.

Member of Tau Beta Pi, Pi Tau Sigma, Phi Kappa Phi, Eta Kappa Nu, Sigma Xi. Registered Professional Engineer, Vice Chairman, Twin Cities Section, AIAA. Within DOT, professional capabilities known to Mr. Charles Baker, 962-5555.

Representative Recent Publications

"Transpiration Cooling of a Constricted Electric-Arc Heater," (with E.R.G. Eckert). AIAA J. Vol. 5, No. 4, pp. 699-706. April, 1967.

"The Inverse Problem in Arc Physics," Phys. of Fluids, Vol. 10, No. 4, pp. 894-896. April, 1967.

"Local Temperature Variations of a Transpiration-Cooled Wall Due to Radiant Heating," J. Heat Transfer, Vol. 90, pp. 146-150. Feb. 1968.

Magnetogasdynamics of Thermal Plasma. To be published by Massachusetts Institute of Technology Press (in Press).

"A Numerical Method to Compute the Distribution of Temperature and Current Density in a Constricted Electric-Arc Heater with Known Velocity Profiles," (with D.K. Hennecke). HTL TR NO. 77. Sept. 1967.

"Difference Equations for the Solution of Axisymmetric Problems in Steady Flow of Gases with Variable Properties and with Electric Heat Addition," HTL TR NO. 80, February, 1968.

John R. Borchert

Education

B.A., DePauw University, 1941.
M.A., University of Wisconsin, 1946, Ph.D., 1949.

Professional Experience

Instructor, University of Wisconsin, 1947-49.
University of Minnesota, 1949 - Present.
- Assistant Professor, 1949-51.
- Associate Professor, 1951-56.
- Professor, 1956 - Present.
- Chairman, Department of Geography, 1956-61.
- Project Director (with Professor Philip M. Raup), Minnesota Highway Research Project, 1958-61.
- Urban Research Director, Upper Midwest Economic Study, 1961-63.
- Associate Dean, Graduate School, and Professor of Geography, winter-spring, summer, 1965.
- Special Assistant to the Vice President for Educational Relationships and Development, 1966-68.
- Director, Center for Urban and Regional Affairs, 1968 - Present.

Professional Membership

Association of American Geographers
American Institute of Planners
American Association of University Professors
National Council for Geographic Education
Urban Land Institute

Professional Service

Member, Social Sciences Advisory Committee, National Science Foundation, 1966 - Present.
Chairman, Earth Sciences Division, National Research Council, 1967-69.
Vice President, Association of American Geographers, 1967-68.
President, Association of American Geographers, 1968-69.

Consultant To:

Environmental Research Division, Office of the Quartermaster General, 1959-55.
Minnesota Highway Department, 1954, 1958.
St. Paul Planning Board, 1957-58.
Hennepin County (Minneapolis area) Highway Department, 1956.
Minnesota Board of Education, intermittently.
St. Paul Board of Education, intermittently.
Minnesota Natural Resources Council, 1962.
Minnesota Outdoor Recreation Resources Commission (standing committee of the legis.), 1964, 1966-67.
St. Paul Housing and Redevelopment Authority, 1965-66.
Senate Highway Committee, Minnesota Legislature, 1966.
U.S. Department of Commerce, Economic Development Administration, Regional Economic Development Institute, Summer, 1967.
Minnesota State Planning Agency, 1966-67.
National Science Foundation, Division of Social Sciences.

Selected Publications

"Time Series Maps for the Projection of Land-Use Patterns" (with Donald D. Carroll), 40th Annual Highway Research Board Meetings, Bulletin 311, Washington: National Academy of Sciences-National Research Council, 1961, pp. 13-26.

"Minnesota Municipalities: 1975 Projections and Possibilities," Minnesota Municipalities, (49) 1964, pp. 236-239, 257.

"Summary of Economic and Geographic Trends and Problems in the Upper Midwest," Nation's Manpower Revolution. (Transcript of Hearings, Subcommittee on Employment and Manpower, Committee on Labor and Public Welfare, U.S. Senate), Washington: U.S. Government Printing Office, November 1963, pp. 2381-2387.

Projection of Population and Highway Traffic in Minnesota. Minneapolis: University of Minnesota Highway Research Project, 1963, 42 pages, maps.

The Urbanization of the Upper Midwest: 1930-1960. Minneapolis: Upper Midwest Economic Study Urban Report No. 2, 1963, 56 pp., maps.

Trade Centers and Trade Areas of the Upper Midwest (with Russell B. Adams), Minneapolis: Upper Midwest Economic Study Urban Report No. 3, 1963, 44 pp., maps.

The Why and How of Community Planning (with Thomas L. Anding, Donald V. Klein, Ellis Waldron, and C. Lee Gilbert), Minneapolis: Upper Midwest Economic Study Urban Report No. 4, 1963, 47 pp., maps.

"Geography and Systems Theory," Chapter 18 in Saul B. Cohen (ed.), Problems and Trends in American Geography, New York: Basic Books, 1967, pp. 264-273.

DARRELL A. FROHRIB, Associate Professor

Biography

Dr. Frohrib received his Bachelor's and Master's degrees in Mechanical Engineering from the Massachusetts Institute of Technology in 1952 and 1953, specializing in applied mechanics and machine design. He received his Ph. D. in Aeronautics and Engineering Mechanics from the University of Minnesota. From 1953 to 1959, Dr. Frohrib was employed at Sperry Gyroscope Company, Long Island, New York, as a group leader in shock and vibration analysis. His responsibilities were in design optimization of defense systems and electro-magnetic devices in shock and vibration environments and in the development and application of shock and vibration instrumentation. Dr. Frohrib teaches dynamics and design in the Design Division of the Mechanical Engineering Department. He also serves as consultant in stress and dynamics analysis to the Univac Division of Sperry Rand Corporation. Dr. Frohrib's research interests are in the design and analysis of systems subjected to dynamic environments, the synthesis of mechanism systems, and in computer solutions of optimization problems in engineering design. He coordinates the Interdepartmental Engineering Design Program in the Departments of Mechanical Engineering, Aeronautics and Engineering Mechanics, and Civil Engineering. The development of a learning center in Socio-Technological Design under the auspices of the Council on Liberal Education is one of his current educational interests.

Representative Recent Publications

"The Optimum Design of Five-Ply Viscoelastic Isolation Flexures for Point Inertia Loading." Proceedings of the 38th Symposium on Shock and Vibration, Dept. of Defense, St. Louis, Missouri, May 1, 1968.

"The Free Vibrations of Stiffened Drill Strings With Static Curvature" (with R. Plunkett). Journal of Engineering for Industry, American Society of Mechanical Engineers, Paper No. 66-Pet. 1.

"The Effect of Inertia Variation and Certain Asymmetries on the Dynamic Response of An Elastically-Coupled System," presented at the 35th Symposium on Shock and Vibration, Dept. of Defense, New Orleans, La., October 26, 1965.

"Designing Flexible Beam Suspensions." Machine Design, July 6 and July 20, 1961.

Current Research

1. Shock and Vibration Design
2. Optimization in Engineering Design in the area of applied mechanics
3. The Synthesis of Mechanisms
4. The Effects of Flexibility in Spatial Mechanisms
5. Optimization of Flexural Strain Energy

Daniel L. Gerlough

Date of Birth: May 31, 1916

Education: B.S. California Institute of Technology, 1937
M.S. Electrical Engineering, University of California, Berkeley, 1948
Ph.D. Engineering, University of California, Los Angeles, 1955

Professional Experience:

1937-1947 Varied industrial and consulting experience
1948-1959 University of California, Los Angeles
1948-1955 Assistant Research Engineer, Institute of Transportation and Traffic Engineering (ITTE) and Lecturer, Department of Engineering
1955-1956 Associate Research Engineer, ITTE and Lecturer, Department of Engineering
1956-1959 Associate Professor of Engineering and Associate Research Engineer, ITTE
1959-1963 Head, Traffic Systems Section, Thompson Ramo Wooldridge, Inc.
1963-1967 Manager, Traffic Systems Section Planning Research Corporation
1967-Present Professor of Transportation Engineering, University of Minnesota

Selected Publications:

Gerlough, D. L., "Simulation of Freeway Traffic by an Electronic Computer," Proceedings of Highway Research Board, 1956, Vol. 35, pp. 543-547.

Brenner, R., J. H. Mathewson, and D. L. Gerlough, "A General Method for Estimating Through Traffic in a Road Network," Highway Research Abstracts, September 1957, Vol. 27, No. 8, pp. 32-44.

Gerlough, D. L., "Control of Automobile Traffic--A Problem in Real-Time Computation," Proceedings of Eastern Joint Computer Conference, 1957, pp. 75-79.

Gerlough, D. L., "A Comparison of Techniques for Simulating the Flow of Discrete Objects," paper presented at the National Simulation Conference, Dallas, Texas, October 23-25, 1958.

Gerlough, D. L., "Applications of Computers to Traffic Problems," Proceedings of Institute of Traffic Engineers, 1958, Vol. 28, pp. 130-136.

Gerlough, D. L., and F. A. Wagner, "Simulation of Traffic in a Large Network of Signalized Intersections," paper presented at the Second International Symposium on Theory of Traffic Flow, London, England, June 25-27, 1963.

Wagner, F. A., Jr., Barnes, F. C., and Gerlough, D. L., Refinement and Testing of Urban Arterial and Network Simulation, PRC-R-1064, Report by Planning Research Corporation to U.S. Bureau of Public Roads, November, 1967.

PROFESSIONAL BIOGRAPHY

Donald Victor Harper
Professor of Transportation and Logistics
Graduate School of Business Administration
University of Minnesota
Minneapolis, Minnesota 55455
Phone: 373-3589

Home Address: 2451 North Sheldon Street
St. Paul, Minnesota 55113
Phone: 633-7368

Birth Date: March 27, 1927 Birth Place: Chicago, Illinois

Marital Status: Married, three children

Military Service: United States Navy, April, 1945 - June, 1946

Education: Ph.D. (Economics), University of Illinois, Urbana, Illinois, 1957
B.S. University of Illinois, Urbana, Illinois, 1950
Wright Junior College, Chicago, Illinois, three semesters in 1944 and 1946-1947.

Positions: Professor, Graduate School of Business Administration, University of Minnesota, 1965-present; Chairman, Department of Management, Production, and Transportation, 1967-present; Associate Professor, 1959-1965; Assistant Professor, 1956-1959; Lecturer, July, 1956-December, 1956
Instructor in Economics (part time), College of Commerce, University of Illinois, 1953-1956
Sales Department, General Mills, Inc., Chicago, Illinois, 1950-1952
Practitioner before the Interstate Commerce Commission
Consultant to private business firms

Professional Memberships:

American Economic Association
Transportation Research Forum
Transportation Club of St. Paul
Northwest Shippers Advisory Board
Traffic Club of Minneapolis
Association of Interstate Commerce Commission Practitioners
Railway Systems and Management Association
American Marketing Association

Research and Publications Completed and in Progress (as of July, 1968)

Books

Economic Regulation of the Motor Trucking Industry by the States, University of Illinois Press, Urbana, Illinois, 1959. (Expansion of Ph.D. dissertation.)

Economic Guidelines for Unemployment Insurance, Minnesota: 1958-67 (with George Seltzer and Others), Minnesota Department of Employment Security, 1959. (Report of study concerning an examination of Minnesota's unemployment insurance program.)

Price Policy and Procedure, Harcourt, Brace, and World, Inc., New York, 1966. (Text for use in marketing courses in price policy and in marketing management courses in which pricing is an important part.)

Monographs

Basic Planning and the Transportation Function in Small Manufacturing Firms, Small Business Management Research Report, School of Business Administration, University of Minnesota, January, 1961. (Report based on research involving 38 personal interviews with small manufacturers in Minnesota relative to their handling of the transportation function.)

Opportunities and Problems for Small Business in Foreign Trade Via the St. Lawrence Seaway (with E. A. Nightingale), Small Business Management Research Report, School of Business Administration, University of Minnesota, November, 1964. (Report based on research involving 1,250 mail questionnaires returned from business firms in the nine-state area covered by the study relative to the nature of foreign trade and the use and potential use of the St. Lawrence Seaway for such trade.)

Marketing Advances (editor), proceedings of 9th Biennial Marketing Institute, Minnesota Chapter, American Marketing Association, November, 1963.

Articles

"Wholesale Trade in Minnesota" (with R. J. Holloway), Greater Minneapolis (centennial issue), January, 1958.

"The Shipper Views Economic Regulation of For-Hire Trucking," Inter-State Commerce Commission Practitioners' Journal, December 1963. (Article based on a study involving ninety-two personal interviews with and mail questionnaires received from industrial traffic managers in Minnesota and Wisconsin relative to their reaction to government economic regulation of the for-hire trucking industry.)

"Transportation: A Forgotten Function of Marketing," Boston University Business Review, Spring, 1964. (Article which deals with the relationship between marketing and transportation (and physical distribution management) in marketing practice and in marketing education.)

"What Next for Transportation Education?" The Transportation Journal, Spring, 1965. (Article which deals with the present status of transportation education in collegiate schools of business administration and developments to be expected and to be encouraged in the future.)

"Economic and Managerial Aspects of State Taxation of Commercial Airlines" (with N. A. Glaskowsky, Jr.). The Transportation Journal, Winter, 1965. (Aritcle which deals with the economic implications of and managerial problems associated with specialized state taxes on the commercial airline industry.)

The following articles appeared in Business News Notes, published by the School of Business Administration, University of Minnesota:

"The Changing Pattern of Minnesota's Retail Trade" (with R. J. Holloway), March, 1957.

"The Wholesale and Service Trades of Minnesota" (with R. J. Holloway), July, 1957.

"Transportation Trends in Minnesota," April, 1959.

Book Reviews

A. J. Bergfeld, J. S. Earley, and W. R. Knobloch, Pricing for Profit and Growth. Reviewed in the Journal of Marketing, October, 1958.

James C. Nelson, Railroad Transportation and Public Policy. Reviewed in the Journal of Marketing, July, 1960.

Roy J. Sampson and Martin T. Farris, Domestic Transportation: Practice, Theory, and Policy. Reviewed in the Journal of Marketing, January, 1967.

Martin T. Farris and Paul T. McElhiney, Modern Transportation: Selected Readings. Reviewed in the Journal of Marketing, April, 1968.

Matthew J. Huber

Date of Birth: September 10, 1924

Education: B.C.E. Marquette University, 1945
M.S.C.E. Michigan State University, 1950
Certificate in Highway Traffic Yale University Bureau of Highway Traffic, 1953
M of E Yale University, 1965
Ph.D. Yale University, 1968

Professional Experience:

1945-1946 U. S. Marine Corps.
1946-1948 City of Milwaukee and Wisconsin State Highway Department
1948-1953 Instructor and Ass't. Prof. - Michigan State Department of Civil Engineering
1955-1968 Research Associate Bureau of Highway Traffic, Yale University
1968 (September) Associate Professor of Transportation Engineering, University of Minnesota

Selected Publications:

"Control of Access to Roads and Streets" Proceedings of the Fortieth Annual Highway Conference, University of Michigan, 1955.

"Effect of Temporary Bridge on Parkway Performance" Highway Research Board, Bulletin 167, 1957.

"Measuring Lateral Placement and Velocity" (co-author with P. H. Thompson) Traffic Engineering, Vol. 31, No. 1, October, 1960.

"Traffic Operations and Driver Performance as Related to Various Conditions of Nighttime Visibility" Highway Research Board, Bulletin 336, 1962.

"Street Travel as Related to Local Parking" Proceedings, Highway Research Board, Vol. 41, 1962.

"Computer Programming for Traffic Problems and Flow Characteristics" in Traffic Control Theory and Instrumentation, ed. by Thomas R. Horton, Plenum Press, New York (1965).

"Traffic Characteristics" in forthcoming text on Highway Traffic Engineering (to be published by Automotive Safety Foundation - Spring 1968).

"Effect of Illumination on Operational Characteristics of Freeways" (co-author with Joseph L. Tracy) (to be published by National Cooperative Highway Research Program - Spring, 1968).

"Predicted Traffic Usage of a Major Highway Facility Versus Actual Usage" (co-author with Harvey B. Boutwell, David K. Witheford) (to be published by National Cooperative Highway Research Program - Spring, 1968).

WARREN E. IBELE, Professor

Biography

Dr. Ibele received his B.S. degree in Mechanical Engineering from Tulane University (1944). Following active duty (U.S. Navy 1944-46) he undertook graduate study at the University of Minnesota receiving a M.S. (1947) and Ph.D. (1953) in Mechanical Engineering. Dr. Ibele has served as Assistant Project Engineer with the Technical and Research Group of Pratt and Whitney Aircraft at intervals for the period 1955-58. He is co-author of Engineering Thermodynamics (1960) a textbook, and editor of Modern Developments in Heat Transfer (1963). He is the author of a number of papers in the area of thermodynamics, transport properties, fluid mechanics, heat and mass transfer. Dr. Ibele is presently Professor of Mechanical Engineering.

Representative Recent Publications

"Prandtl Number Measurements and Transport Property Calculations for N_2 - CO_2 Mixtures," (with D. G. Briggs). Pages 392-97 in Proceedings of the Fourth Symposium on Thermophysical Properties. (Editor : J. R. Moszynski). New York: The American Society of Mechanical Engineers, 1968.

"Interface Resistance and Stability in Laminar Film Condensation Heat Transfer," (with D. L. Spencer). JSME 1967 Semi-International Symposium, Tokyo, September 4-8, 1967, in Heat and Mass Transfer, Thermal Stress, Vo. II, pp. 99-104. The Japan Society of Mechanical Engineers, Tokyo.

"Experimental Anode Heat-Transfer Studies in a Coaxial Arc Configuration," (with K. T. Shih, E. Pfender, and E. R. G. Eckert). AIAA J. Vol. 6, No. 8, pp. 1482-87, August, 1968.

Current Research

Investigation of thermodynamic and transport properties of gases and gas mixtures by experiment and theory.

1) Gas viscosity measurements by means of porous plug.

2) Local heat transfer on vertical plate in natural convection in presence of turbulence promoters.

3) Diffusion coefficient and thermal diffusion factors for binary gas systems determined from measurement of temperature and concentration profiles.

4) Steady state-hot-wire cell for gas thermal conductivity determination of gases and gas mixtures.

5) Theoretical studies including statistical thermodynamic investigation of transport properties of pure gases and gas mixtures, and irreversible thermodynamics.

6) Measurements in pipe flow - with orifices.

Resume

Name: K. S. P. Kumar

Date of Birth: May 12, 1935

Address: Department of Electrical Engineering, University of Minnesota, Minneapolis, Minnesota 55455

Telephone: 373-5228

Educational Background:

B.Sc.	Mysore University, India	1953
M.Sc. (Physics)	Karnatak University, India	1955
D.I.I.Sc. (Electrical Communication Engineering)	Indian Institute of Science, India	1958
M.S.E.E.	Purdue University, U.S.A.	1961
Ph.D.	Purdue University, U.S.A.	1964

Work Experience:

1967 -	Associate Professor, Dept. of Elec. Eng., University Minnesota, Minneapolis, Minnesota, U.S.A.
1964 - 1967	Assistant Professor, Dept. of Elec. Eng., University of Minnesota, Minneapolis, Minnesota, U.S.A.
1964	Post Doctoral Research Fellow, School of Electrical Engineering, Purdue University, Lafayette, Indiana, U.S.A.
1964 (summer)	Engineering Specialist, Applied Research Laboratory, Sylvania, Waltham, Massachusetts, U.S.A.

1963	Instructor, School of Electrical Engineering, Purdue University, Lafayette, Indiana, U.S.A.
1962 (summer)	Senior Research Engineer, Honeywell, Minneapolis, Minnesota, U.S.A.
1961 (summer)	Visiting Scientist, Research Institute for Advanced Studies (RIAS), Baltimore, Maryland, U.S.A.
1961-1963	Fellowship of the Purdue Research Foundation, Purdue University, Lafayette, Indiana, U.S.A.
1959-1961	Graduate Teaching Assistant, School of Electrical Engineering, Purdue University, Lafayette, Indiana, U.S.A.
1958-1959	Technical Assistant, Department of Electrical Communication Engineering, Indian Institute of Science, Bangalore, India

Consulation Experience:

1965	General Mills, Inc., Minneapolis, Minnesota
1964-1967	UNIVAC, Aerospace Analysis Group, St. Paul, Minnesota
1967 -	3M Company, St. Paul, Minnesota

Professional Societies:

Member Eta Kappa Nu, Sigma Xi, IEEE

Courses Taught at Minnesota:

EE 194-195-196: First year graduate course in control theory.

EE 297A-B-C: Graduate course in nonlinear systems.

EE 294-295-296: Graduate course in control theory.

EE 107: Linear systems for Juniors.

Publications:

1. On the Space Charge Limited Current-Flow from a Cylindrical Cathode to a Pair of Parallel Plane Anodes (Co-authored with S. Sampath), Electrotechnics, No. 26, pp. 74-80, 1959.

2. A New R.M.S. Describing Function for Single-Valued Nonlinearities (Co-authored with J. E. Gibson), Proc. of I.R.E., Vol. 49, No. 8, p. 1321, August 1961.

3. Statistical Design of Discrete Data Control Systems Subject to a Power Limitation (Co-authored with J. T. Tou), J. of Franklin Institute, Vol. 272, No. 3, pp. 171-184, September 1961.

4. On the Identification of Control Systems by the Quasilinearization Method, (Co-authored with R. Sridhar), IEEE Trans. on Automatic Control, April 1964.

5. Editor of "Modern Aspects of Automatic Control", published by School of Electrical Engineering, Purdue University, 1963.

6. On Combined Identification and Control (Co-authored with R. Sridhar), January 1964, IEEE Trans. on Automatic Control, Correspondence.

7. On the Identification of Control Systems (Co-authored with R. Sridhar), JACC, Stanford, 1964.

8. On the Utilization of Digital Computers in Control Systems, Advances in Control Systems, University of Wisconsin, Madison, Wisconsin, 1964.

9. On the Identification of Nonlinear, Nonstationary Processes, IFAC Tokyo Symposium, Tokyo, Japan, August 1965.

10. On the Optimum Stabilization of a Satellite, IEEE Trans. on Aeropsace and Electronic Systems, Vol. AES 1, No. 2, pp. 82-83, October 1965.

11. Discrete Differential Approximation, Proc. IEEE (Correspondence), Vol. 54, No. 1, pp. 64-65, January 1966.

12. On a Fixed End Point Regulator Problem, IEEE Trans. on Automatic Control, Vol. AC-11, No. 2, p. 310, April 1966.

13. **Stabilization of a Satellite Via Specific Optimum Control (Co-authored with L. Teng), IEEE Trans. on Aerospace and Electronic Systems, Vol. AES-2, No. 4, pp. 446-449, July 1966.**

14. **Optimum Control for Lunar Soft Landing (Co-authored with L. Teng), 17th International Astronautical Congress, Madrid, Spain, October 1966.**

15. Sensitivity Considerations in Specific Optimum Control (Co-authored with R. J. Burns), Int. Journal of Control, Vol. 5, No. 3, pp. 289, 296, 1967.

16. Discrete Differential Approximation and System Identification, Int. Journal of Control, Vol. 6, No. 1, pp. 27-32, 1967.

17. Synthesis of Suboptimal Feedback Controls for a Class of Distributed Parameter Systems (Co-authored with J. H. Seinfeld), 18 pp, accepted for publication.

18. Successive Linearization and Nonlinear Filtering (Co-authored with S. Kau), submitted for publication.

DEPARTMENT OF ECONOMICS
UNIVERSITY OF MINNESOTA
MINNEAPOLIS, MINNESOTA 55455

Name: James Dean Likens

Address: 3933 Bryant Ave. So.
Minneapolis, Minnesota 55409
Tel 612-825-5061

Office: Department of Economics
University of Minnesota
Tel 612-373-4386

Age: 31

Marital Status: Married

Citizenship: U. S.

Military Service: Completed

Education:

1960. AB, Economics (with honors), University of California (Berkeley)
1961 MBA, Bus. Admin. (Marketing), University of California (Berkeley)
1963-date, University of Minnesota, Ph.D. candidate

Thesis Topic:

"The Welfare Costs of Non-optimal Airport Utilization: A Case Study of the Washington-Baltimore Airports"

Thesis Adviser:

Professor Herbert D. Mohring

Expected Date of Ph.D. Degree:

June 1968

Major Fields of Interest:

Economic Theory, Industrial Organization, Labor Economics

Minor Fields of Interest:

Comparative Systems, Soviet Economics, Money & Banking
History of Economic Thought, Business Administration (Marketing)

Honors: CLA Tuition Scholarship
Cited for excellence in teaching, university-wide course evaluation

Experience:

1960-61, Research Assistant, Univ. of Calif. (Berkeley), leading to Lee E. Preston, "Markups, Leaders, and Discrimination in Retail Pricing." Journal of Farm Economics, May 1962.

1962-63. Economic & Market Research Analyst, Del Monte Food Corporation, prepared company and industry position on Trade Exmansion Act and Kennedy Tariff Round.

1963-64, assisted in writing Harlan Smith, ed., Study Guide for Selected Sixty Session Series of The American Economy TV Films, Joint Council on Economic Education, 1964.

1963-64, Instructor, Wisconsin State University (Course: Economic History of the United States).

1964-65, Marketing Research Analyst, Stephen K. Plasman & Associates, (consultants), Minneapolis.

1967-68, consulted for Minnesota Mining and Manufacturing Company, writing unpublished (proprietary) economic analysis of the air transport industry (269 pages).

1964-date. Instructor, University of Minnesota (Courses: Principles of Economics, Intermediate Micro Theory, Industrial Organization).

References: (all professors of economics, University of Minnesota)
Herbert D. Mohring (Adviser), Peter Gregory, E Scott Maynes, Edward Coen, John Buttrick (Director of Graduate Studies), Norman Simler (Chrm.)

Herbert Mohring

Date of Birth: September 8, 1928

Education: A. B. Williams College, 1950, Economics, Mathematics
Ph.D. Massachusetts Institute of Technology, 1959, Economics

Professional Experience:

1951-1952	Research Associate; University of Michigan; Willow Run Research Center
1952-1954	Teaching Fellow; M.I.T.; Department of Economics
1954-1957	Assistant Study Director, Study Director, University of Michigan, Survey Research Center
1957-1958	Research Associate; Resources for the Future, Inc.
1958-1961	Research Economist; Transportation Center at Northwestern University
3-7/1961	Consultant; Northwestern University, Department of Economics, Economic Survey of Liberia
1961-1967	Associate Professor; Department of Economics, University of Minnesota
1967-Present	Professor, Department of Economics, University of Minnesota

Selected Publications:

Highway Benefits: An Analytical Framework, Evanston: Northwestern University Press, 1962 (joint author with Mitchell Harwitz).

"Land Value and the Measurement of Highway Benefits," Journal of Political Economy, June 1961.

"The Place of Subsidies in an Optimum Transportation System," Highway Research Record, Number 20,1963.

"Urban Highway Investments," in Robert Dorfman, Editor, Measuring Benefits of Government Investments. Washington: Brookings Institution 1965, pp. 231-275, 288-291.

"The Relation Between Optimum Congestion Tolls and Present Highway User Charges," Highway Research Record, No. 47, (1964), pp. 1-14.

Transportation Economics, New York: Random House (forthcoming).

DEPARTMENT OF ECONOMICS
UNIVERSITY OF MINNESOTA
MINNEAPOLIS, MINNESOTA 55455

Name: Thomas Pinfold

Age: 28

Address: 3423 - E. 26th Street
Minneapolis, Minnesota 55406
Tel: 612-724-4845

Marital Status: Married

Citizenship: Canadian

Office: 304 Center for Economic Research
University of Minnesota
Tel: 612-373-5553

Education:

1963, B.A., Economics - University of Western Ontario
1965, M.A., Economics - University of Western Ontario
1965-present, University of Minnesota, Ph.D. candidate

Thesis Topic:

"The Modal Split Problem in Urban Transportation"

Thesis Adviser:

Professor Herbert Mohring

Expected Date of Ph.D. Degree:

June 1969

Major Fields of Interest:

Economic Theory, International Trade, Econometrics

Minor Fields:

Mathematics, Statistics

Experience:

Teaching

Teaching Assistant at Western Ontario: 1963-64, 1965-65, responsible for conducting two tutorial sessions per week for 10-15 students, which involved lectures on particular problems to amplify the professor's lectures and answering student questions about home problems and exams.

Teaching Assistant at Minnesota: 1966-67, assisted Professor John Buttrick with a senior undergraduate course in Welfare Economics; in addition to grading, I was responsible for class discussion of examinations and home problems.

Research

Research Assistant at Western Ontario: Summer 1965 for Professor G. L. Reuber; duties consisted of compiling articles on Canada in the international economy for a book of readings edited by Professor Reuber and Professor H. E. English to be published in The Carleton Library series.

Research Assistant at Minnesota: 1965-68 to Professor Herbert Mohring in various research projects. Through this period my responsibilities included (1) developing quantitative evidence on the relative importance of alternative inputs in the petroleum refining industry; and, generating evidence on the importance of tariff structure for petroleum and petroleum products as it affects production location in the US petroleum refining industry; (2) independent development and checking of mathematical models to be used for computer simulation in welfare loss problems and deriving quantitative estimates of the benefit measures for specific examples; (3) developing evidence of the impact of collusion in the rock salt industry on the price of rock salt through analysis of the geographical price structure in the state of Minnesota.

Some results of this work may be found in: Herbert Mohring, Marvin Kraus and Thomas Pinfold, "The Welfare Costs of Non-Optimal Pricing and Investment Policies for Urban Freeways," February, 1969. Other results are contained in Professor Mohring's recent and near future publications.

As a by-product of the project on the welfare costs of non-optimal pricing and investment policies, I transalted, Marcel Boiteux, "Sur la Gestion des Monopoles Public Astreints à l Equilibre Bugetaire," Econometrica, January, 1956, pp. 22-40. I expect this article will appear in a book of translated articles in preparation by Professor John Chipman.

Fellowships:

Ontario Graduate Fellowship 1964-65 (1965-66 Awarded, but declined)
Canada Council Doctoral Fellowship 1968-69

References:

Professor Herbert Mohring
Department of Economics
University of Minnesota

Professor John A. Buttrick
Department of Economics
University of Minnesota

Professor Clifford Hildreth
Department of Economics
University of Minnesota

Thomas M. Scott

Education: B.A. College of Wooster, 1959
Ph.D. Northwestern University, 1964

Professional Rank: Associate Professor of Political Science,
University of Minnesota

Selected Publications:

"Election Legislation," Book of the States, 1968-69, Chicago, Council of State Governments, 1968, 19-22.

"Metropolitan Governmental Reorganization Proposals," Western Political Quarterly, Vol. 21, No. 2, June, 1968, pp. 252-261.

"The Diffusion of Urban Governmental Forms as a Case of Social Learning," Journal of Politics, forthcoming, November, 1968, about 12 pages.

APPENDIX B

LETTERS FROM GOVERNMENT AGENCIES AND PRIVATE INDUSTRY

Phone 227-7343 Area 612

TWIN CITIES AREA METROPOLITAN TRANSIT COMMISSION

106 Capitol Square Building, 550 Cedar at 10th Street East, Saint Paul, Minnesota 55101

December 27, 1968

Center for Urban and
Regional Affairs
Room 311
Walter Library
University of Minnesota
Minneapolis, MN 55455

PROFESSOR D L GERLOUGH

Gentlemen

I'm writing to indicate the great interest of the Transit Commission in your proposed program in urban transportation.

We expect to participate strongly in this program. Our participation would include but not be limited to providing seminar speakers and providing internships to appropriate candidates.

Sincerely

Les Bolstad Jr

Les Bolstad Jr
Chairman

kw

STATE OF MINNESOTA
DEPARTMENT OF HIGHWAYS
ST. PAUL, MINN. 55101

December 30, 1968

Dr. Daniel Gerlough
University of Minnesota
Institute of Technology
Department of Civil Engineering
Minneapolis, Minnesota 55455

Re: Proposed Urban Transportation
Program - University of Minnesota

Dear Dr. Gerlough:

Recognizing the need for developing urban transportation training programs at the University of Minnesota, we are anxious to cooperate with you and your staff to the extent possible in developing a program for training and research at the University.

As additional details are developed for the proposed educational program, we will be in a better position to indicate in what way and to what degree we will be able to be of assistance.

Sincerely,

Lynn M. Carlson

Lynn M. Carlson
Assistant Commissioner

STATE OF MINNESOTA
STATE PLANNING AGENCY
SAINT PAUL

January 17, 1969

Professor Daniel Gerlough
Center for Urban and Regional Affairs
University of Minnesota
Minneapolis, Minnesota 55455

Dear Professor Gerlough:

It is our understanding that you wish the Minnesota State Planning Agency to be represented on an Agency Advisory Panel being considered in relation to the Program in Urban Transportation being proposed by the University of Minnesota.

We would, of course, be willing to participate as members of such an advisory panel. Further, we are very pleased that the University is setting up the transportation program and especially wish to commend its multi-disciplinary nature.

Sincerely,

Raymond T. Olsen
State Planning Director

RTO/rl

CORPORATE HEADQUARTERS
8100 34TH AVENUE SOUTH, MINNEAPOLIS, MINNESOTA 55440 / 612-888-5555 / TWX 910-576-2978

CONTROL DATA
CORPORATION

December 23, 1968

Progessor J. E. Anderson
Mechanical Engineering Department
University of Minnesota
Minneapolis, Minnesota

Dear Professor Anderson:

This letter is to affirm the position of the Twin Cities Data Center of Control Data Corporation in the field of urban affairs in general and, specifically, transportation planning.

Twin Cities Data Center is vitally interested in the transportation needs of the Upper Midwest. It is our contention that many current urban problems in this geographic area are due to inadequate transportation facilities and to many of the stopgap measures employed thus far in answer to transportation problems.

Two serious shortages, among others, currently exist: first the almost total void of mass transit facilities; second, the lack of trained transportation planning analysts. For these and other reasons, we have invested over half a million dollars in developing a Transportation Planning computer system (TP) on our 3600 computer. This system represents one of the best tools available anywhere to assist the transportation planning analyst in preparing the statistical summaries of mathematical simulations inherent to the transportation planning analyst.

Because we feel a heavy responsibility in this area of interest, we have offered the use of TP at no additional charge over our normal computer rental rates. Thus, the user of TP is not asked to share in the development cost of the system.

We are extremely pleased to know that the University of Minnesota is interested in assisting in the alleviation of the shortages mentioned above (viz., mass transit and transportation planning research and training). We would like to assist the University of Minnesota in any way that we can. To this end, I would like to suggest the use of TP mentioned above; for the latter, it could be used by students for test cases, papers and homework assignments.

We would be willing to give to your department at no charge a copy of our TP User Information Manual (an eight volume up-to-date set which normally retails for over $300.00) for your evolution of TP for the purposes herein described. Furthermore, we have available trained transportation planning analysts located in Minneapolis who can consult and, if necessary, instruct in the use of TP or in transportation planning theory in general.

I sincerely hope that our products and services can be useful to you in your current and future endeavors. The problems involved are of deep mutual interest, and are problems that severely need solutions. Thank you for giving us this opportunity to express our interest and position, and thank you in advance for your cooperation in this matter of vital concern.

Sincerely yours,

CONTROL DATA CORPORATION
Twin Cities Data Center

Ronald W. Henry

Ronald W. Henry
Supervisor/Urban
Affairs Section

RWH:ss
cc: P. L. Bayles
R. R. Burns
K. E. Haeberle
D. T. Jarvis
D. F. Pitt
R. O. Young

ROSEMOUNT
ENGINEERING COMPANY

4900 West 78th Street Minneapolis, Minnesota 55435
Phone: 612-927-7711 TWX: 612-292-4136 TELEX: 029-692
CABLE: ROSEMOUNT

9 December 1968

Dr. E. Anderson
Department of Mechanical Engineering
125 Mechanical Engineering Building
University of Minnesota
Minneapolis, Minnesota 55455

Dear Dr. Anderson:

Rosemount Engineering Company is currently engaged in research and development related to the Uniflo transportation system. This transportation system is applicable to materials handling and people moving. As a people moving system it provides high speed, non-stop service on demand from closely spaced stations. Such service requires the use of small vehicles travelling at constant speed over the transit route.

The Uniflo transportation system is one of several personalized urban mass transit systems that utilize small vehicles and provide the type of service described above. Although these systems differ in the mechanical implementation, the system's operational problems related to traffic control is common to all of the systems. So far as we know, no one has simulated this type of transit system on a computer. Rosemount feels that such a simulation should be done and that it would be of direct value to all of the organizations developing personalized urban transit systems.

Rosemount Engineering Company would be pleased to explore with you and your associates how we might contribute to a computer simulation of a personalized urban transit system.

Sincerely,

Lloyd E. Berggren

Lloyd E. Berggren

LEB:agb

APPENDIX C

TRAINING PROGRAM IN MASS TRANSPORTATION SYSTEM ENGINEERING

TRAINING PROGRAM IN MASS TRANSPORTATION SYSTEM ENGINEERING

Objectives of the Program

In recent years, considerable effort has been directed toward the development of educational methods for instructing students in techniques for synthesizing large-scale systems embodying widely diversified technical and social disciplines. Principal among these methods appears to be the identification of a morphology -- and more recently, an anatomy -- of design. In part, this characterization is directed at the effective use of individual talents and group effort to accomplish design activity. Emphasis is placed on the conceptual steps in the design process, such as problem definition with constraints and criteria, alternative solutions and feasibility, preliminary and detailed design, and their interaction.

The University of Minnesota has emphasized a systems approach to design in its undergraduate instructional program for nearly a decade. A Design Center has been developed to coordinate an interdepartmental program of design education between the Departments of Aeronautics and Engineering Mechanics, Civil Engineering, and Mechanical Engineering. Experimental educational programs have been developed to determine the value of teaching systems design in various ways. This program involves approximately 150 students and an instructional staff of eight, including two adjunct staff in senior design capacities in Twin Cities industry. Instructional efforts of this kind have resulted in a better understanding of the design process itself. Yet, such study must still be conducted to develop finesse in instruction of design morphology in the context of types of systems problems.

The need for the interdisciplinary approach is especially apparent in instruction in mass transportation system design. Here, the social and behavioral disciplines govern the success of the system to great degree. The integration of those disciplines into design effort should not be in an "after the fact" sense, but, in the early design stages. Very real continuity and trade-off between social and technological disciplines is required to allow the systems study to net satisfactory functional performance from the user standpoint. A very real commitment on the

part of several important areas of human discipline is required early in the design effort to accomplish this. A clear statement of design objectives, criteria and constraints must be evolved in a manner to include all disciplines in a balanced fashion. Of course, these objectives may be altered iteratively as the effort progresses. Then, however, the reasons for design changes, and the sensitivity of the solution to criteria can be understood and used as a basis for design refinement as transportation technology evolves. Under present techniques of transportation system design, this is very difficult to accomplish.

Problems to Be Investigated

Very few training programs exist to instruct the undergraduate and graduate student in the processes of design for large-scale "human use" systems. Therefore, this training program would address the following specific problems:

The development of educational methods for training systems engineers in the synthesis of urban transportation systems to include the human user--and community--as a first-order factor in the design.

The statement of performance criteria including social factors in a manner that is meaningful to the on-line designer. Presently, it is unclear when certain criteria should be introduced, and in what form. For example, if a human comfort index is identifiable, should it be regarded before an index of convenience and/or flexibility of a transportation mode, and how should the designer utilize such criteria in his effort?

Investigation of the management of urban transportation design effort in the context of hierarchy of responsibility. An organizational structure is required to establish responsibility in any large design effort. However, this structure is very dependent on the type of system under design. The order of responsibility and availability of talent are two important factors in establishing the organization hierarchy. Various organizational structures would be developed for various tasks in transportation system design to provide guidelines for organization of actual effort in urban design. This would include

the interaction between social and political scientists, economists and engineers in the on-going process of design. An attempt would also be made to identify the roles of the specialist in urban transportation and the experienced design engineer in the hierarchy of responsibility.

An emphasis on quantification of the design problem in a realistic fashion to fully realize the potential of operational and trade-off methods without compromising first-order performance requirements.

Methods to Be Used

The core of the instructional program would be that of organized interdisciplinary team effort in evolving solutions to open-ended problems in transportation design. The inter-departmental design program administered through the Mechanical Enginerring Design Center is an excellent vehicle for carrying out the specified objectives. Potential exists for the establishment of design teams with organized responsibility levels involving both undergraduate and graduate students. In a field as broad as urban transportation, advanced course work in technique is of questionable value without experience in on-line design which identifies the utility of subject matter. Therefore, graduate students would act in the dual capacity of team leaders in actual design activity and as students participating in seminars and specific graduate course study. This would provide an excellent way to meld education with research.

Considerable experience has already been acquired in the execution of large systems design involving as many as thirty students in a given study. For example, currently the Inter-departmental Design Program is pursuing the following projects:

--The design of an Electric Automobile

--The design of a Mass Transportation System of the Twin Cities

--The design of a Metropolitan-Wide Waste-Disposal System

--The design of a High-Speed, Long-Distance Air Transportation System

--The design of an Ocean Food-Retrieval System

--An Architecture-Mechanical Engineering Coordination in Urban Renewal Planning for the Southwest Quadrant of Minneapolis

--The design of a Learning Center in Socio-Technological Design

The Learning Center in Socio-Technological Design is currently being planned for the University under the sponsorship of the University's Council of Liberal Education. Its intent is to provide a specific vehicle for communication and design interaction between several discipline areas that bear heavily on the design environment. In this capacity it would fortify the interchange of information between the social and behavioral disciplines, economics, architecture and engineering technology as they bear on the transportation problems. Appendix E describes this center and its purpose.

Senior undergraduate students would form the bulk of the project complement. They would be organized into sub-teams with specific responsibilities in a fashion similar to systems design in an industrial environment. Each project would be under the overall leadership of a senior staff member of the University.

Graduate student involvement would be in the form of teaching associates who would actively contribute to design effort as team leaders with their own design responsibility. The University's newly-created Master of Engineering Degree would be particularly valuable as a vehicle for supplying graduate candidates for such assistantships. A description of this Degree Program is enclosed in Appendix F. It emphasizes design capability rather than research as its principal motif and opens the portals to graduate education for those students with design interests and ability based on criteria other than the traditional Grade Point Average base.

APPENDIX D

UNIVERSITY OF MINNESOTA COMPUTER FACILITIES

UNIVERSITY OF MINNESOTA COMPUTER FACILITIES

Location	Digital Computers	Analog/Hybrid Computers
Computer Center	CDC 6600 CDC 1604 CDC 160	Two EAI 680
Department of Civil Engineering	CTS Terminal	EAI 580
Department of Electrical Engineering	Com Share Terminal	
Department of Mechanical Engineering	CTS Terminal	
West Bank Computer Center (used by School of Business Administration and various social science departments)	CDC 3200 tied to the CDC 6600 at the Computer Center IBM 1620	

Other computers are available in:

Biomedical Data Processing Center
St. Paul Campus Computing Center
Data Processing Center
Center for Human Learning

APPENDIX E

A LEARNING CENTER IN SOCIO-TECHNOLOGICAL DESIGN

[illegible]

PROPOSAL II.

A Learning Center in Socio-Technological Design

by

Professor [illegible] A. [illegible]
Department of Mechanical Engineering

ABSTRACT

This proposal defines a Learning Center that would provide a site and opportunity to establish an ongoing educational program between several departments of the University whose disciplines relate to the process of Design, and which currently lack communication in this vital activity area. The lack of understanding of the impact of engineering on society, and the manner that social disciplines can best be included in the definition of the mission of Design as well as its execution motivates this proposal. The Learning Center would evolve over a two-year interval during which staff, and faculty-student interaction between departments would establish a plan for continuing socio-technological Design education.

INDEX

I. INTRODUCTION

The definition of "Learning Centers" set forth in the January 24 Invitation for Learning Center Proposals has stimulated this proposal from the Design Center of the Mechanical Engineering Department. The motivation originates in the desire to define educational programs which have a specific motif and which have as an objective the development of a "liberating" educational experience.

Only in recent years has the engineering profession become sensitive to its total responsibility in the translation of scientific discipline into workable systems and products to serve mankind. Prior to that time, inventors developed solutions to certain sensed needs in the physical world by personal--and localized--effort by one or a very few investigators. Most of the classical inventions evolved in this manner, including those of Edison, Marconi, Ford and Bell. Whereas these developments were often on the highest plane of ingenuity and dedication, neither the inventors nor the societies in which they lived sensed the magnitude of the social implications of their work on mankind. Perhaps early invention could not have occurred if it had been encumbered by such considerations. However, this lack of perspective has been perpetuated on a larger and larger scale, until today we witness a somewhat schizophrenic sense of responsibility on the part of both the engineer and consumer. We identify the dilemmas of resource pollution and the subjugation of human values to technological ends as consequences of this condition.

The modern university also contributes to the perpetuation of this separation between technology and the social sciences. Severe dissatisfaction exist between curricula in liberal and technological education that free elective courses cannot hope to resolve. However, in certain areas of human endeavor we are now aware of the unification of disciplines needed to fully utilize and channel technological contributions. Quantitative psychology, bio-engineering, and architecture are examples. This suggests the need to identify and correlate the human and technical sciences

within undergraduate curricula by direct dynamic involvement in their mutual issues. This need is enforced by recent trends in engineering education, whereby the design process is subjected to increasing quantification and automation. Already certain phases of design have been automated to provide rapid output, largely through the capability of the high-speed automatic computer. However, the structure of the design process itself, and its use of human personnel, has only begun to submit to these efforts. One realizes that if conceptual design can be quantified, if it can be made to rapidly translate creative involvement into products, the creative personnel must comprehend more clearly than ever the more total implications of their activity.

Over-view non-technical elective courses cannot fully succeed in the role of correlating the engineer with his social responsibilities. These issues are forcefully met when open-ended endeavor such as design is undertaken, where ambiguities, problem definition, and ethical issues are encountered and which require a personal and group commitment.

II. DESCRIPTION OF THE EDUCATIONAL PLAN; SELECTION OF STAFF AND STUDENTS

Since 1962, the Department of Mechanical Engineering has taught Interdisciplinary Design as a formal program to all senior undergraduate students. The program has taught through open-ended project activity in which senior staff members meet in four-hour weekly sessions with student groups to pursue a wide variety of interdisciplinary projects. Approximately six senior staff and eighty students simultaneously participate in this program. This year, to further emphasize interdisciplinary design, four departments of the Institute of Technology* have embarked on an engineering design program which is intended as an experiment in design

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* Aeronautics and Engineering Mechanics, Civil and Mechanical Engineering, and Mines and Metallurgy.

[illegible] to establish the most meaningful educational [illegible] design [illegible] an integrated description of the program [illegible] flow-chart of the building experience is provided. [illegible] physical plant and design parameters is addressed in the [illegible] is further [illegible] the effect of background, skill level and [illegible] environment on the [illegible] design performance.

The [illegible] of a Design Center has been [illegible] by the University [illegible], including approximately 5,000 square feet of space allotted to a central facility with student and staff conference rooms, design library-[illegible] need pinching and time-sharing computer terminals, and a [illegible] coordinator's office. This center is located in Mechanical Engineering 3.1. A group of adjunct staff representing various disciplines from industry will also be introduced into the program during the Spring Quarter, 1968, to guide student project activity.

This interdepartmental commitment to design education has attracted considerable attention as a unique approach to the acquisition of meaningful data concerning design education. It offers a natural opportunity to include participation by staff and students in the humane and environmental sciences and in the hands-on fabricating shops program. The program is divided into three stages, each representing one academic year.

A. First Year

Purpose: To establish sponsored staff communications between certain areas of technology and the human sciences which bear heavily on each other in contemporary design. This communication would involve research, [illegible] for a structured one-year program in design education involving a truly interdisciplinary mix of students from the participating departments.

Description: The first year's program would involve approximately five staff members, one each from departments such as Mechanical Engineering, Law, Psychology, Business and Sociology, on 1/4 time appointment in this program. The criteria for staff selection would be that: (1) possi-

objectives for student learning, (2) those departments responsible for the teaching of design, (3) they have an agreement on plans for the future administration of the program, (4) they have a budget to support the teaching, and (5) they have a preliminary agreement with the student body concerning the selection and recruitment of design students.

One or two small pilot projects should be undertaken and would also be encouraged. Individual candidates can be found and a decision made for the pilot to be encouraged. Where students should be selected, should have an active interest in human problems in the built environment, design and its impact on society, should be diverse in experience and capable of positive interaction with others, should agree to remain in the program throughout the academic year, and should not have a predetermined grade point average.

There has to be ready people would be selected to participate in observations of teaching activity in each participating department in design, behavioral, or subject matter courses that involve students in urban planning identified with the design function. Their responsibility would be to generate a beneficial impact at the end of the first year that would recommend a learning experiment to effectively mold disciplines, skills, and an appropriate number of students from each department for the second phase of the program. Participation would mean weekly for three to four hours by appropriate groups to observe teaching activity on four kinds of questions concerning the second year's teaching experiment.

2. [illegible]

Purpose: To [illegible] teaching experience in design involving [illegible] staff and/or student body demand from the various participating departments. This experience is intended to define the communication problems, effect of ethical commitment, and subject matter background on both the design solution and the perspective gained by participants at the senior undergraduate level.

Description: It is proposed that one staff member from each participating department--preferably the same staff complement as the first year--guide the second year's activity. The first year's terminal recommendations would establish the details of the experiment. It is anticipated that 5 staff members and 50 students might be involved. Student participation need not be evenly distributed between departments, yet a sufficient proportion should be available from each to effectively influence activity. Both lecture and work-shop activity would be included in the one-year effort. One approach would be to establish design project activity in a way to require the interaction between sub-groups with legal, sociological, and technical backgrounds, as an example. Each group would have its specific charge, yet each would be required to cooperate toward the stated goals of the project. Each staff member would act in an advisory and lecturership activity, compatible with 1/4 time appointments. Project reports, seminars, and review would be the basis for assessing student performance.

This program would not interact with, or compromise, the design teaching program currently being conducted

lectures for Departments of Aeronautical Engineering, Engineering Mechanics, Civil and Mechanical Engineering, and Mines and Metallurgy. Engineering student participation would be largely from the Mechanical Engineering Department. If the above departments of engineering would be interested in providing one or two students for the teaching experiment, they would be welcomed.

Student credit would be 3 credits per quarter, and would be used to satisfy an elective course requirement in their academic programs.

C. Subsequent Years

It is anticipated that the experience gained in this socio-technological experiment will evolve a mission that would effectively use the Learning Center perpetually, and would justify the requested second year housing expense.

III. SPACE NEEDS

During the first year of the program, the present facilities of the Mechanical Engineering Design Center would provide adequate housing for staff discussions and conferences. Therefore, no first-year Learning Center costs will be identified with housing.

The ensuing experimental program of the second year, as well as subsequent growth would require additional space. It appears that a second floor of approximately 1,000 square feet would be necessary to house staff lounge and project work functions, as well as interdepartmental staff offices for use during designated periods of activity. It appears logical to locate such an addition adjacent to the learning center to fully utilize the library and computational facilities.

IV. SUPPORTING STAFF INTEREST

Essentially the entire senior staff of the Mechanical Engineering Department has accepted appointments on a rotation basis to teach engineering design in the six years since the program was initiated. The

present Interdepartmental Engineering Design Program is the product of deliberations of an Institute of Technology Committee on Design involving the following people:

D. Frohrib, Assistant Professor of Mechanical Engineering

C. Fairhurst, Professor and Associate Head of Mines and Metallurgy

J. Hawley, Associate Professor of Civil Engineering

B. Hamby, Associate Professor and Associate Head of Electrical Engineering

R. Jordan, Professor and Head of the School of Mechanical and Aerospace Engineering

W. Kleinhans, Associate Professor of Mechanical Engineering

R. Plunkett, Professor of Aeronautics and Engineering Mechanics

L. Scriven, Professor of Chemical Engineering

Professors of Psychology Ralph Beedie and Marvin Dunnette of the Student Life Studies and the Student Counselling Bureau have participated in guidance and recommendation for psychological testing of students and have expressed considerable interest in potential research affiliated with human involvement in design and creativity. The author has had interesting discussions with Professors James Jenkins and Russel Burris of the Department of Psychology, who agree with the desirability for additional research in human factors in design and their impact on design education.

Dean Paul Grambach of the School of Business Administration has expressed considerable interest in the deliberations of the Design Committee mentioned above, as well as the future growth of the educational program.

This staff expression of interest promises very positive cooperation in identifying active participation from several social discipline areas as well as from within the Institute of Technology if financial support can be realized. A Learning Center grant would appear to be the right catalyst to develop specific interaction between such departments to realize the proposed educational program.

APPENDIX F

MASTER OF ENGINEERING PROGRAM

TO: Institute of Technology Faculty

FROM: Joint I.T. -Graduate School Committee on Graduate Programs in Engineering

Attached for your review and consideration is a revision of the document mailed to you in September which proposes the institution of the Master of Engineering program. This revised document, aside from some small changes, attempts to clarify somewhat further the respective roles of the engineering program committees and the Joint I.T.-Graduate School Professional Masters Committee. In addition, discussion of the educative philosophy associated with the program is somewhat expanded.

This document will be brought for action to the I.T. faculty at the November 26 meeting.

November 15, 1968

The Deans of the Graduate School and of the Institute of Technology appointed an ad hoc committee on April 1, 1965, "to discuss possible implications for graduate study of the change to a 4-year baccalaureate program, . . ." This committee, with some change in membership, has devised a concrete program which it would like you to consider prior to its formal submission to the faculty at the December 1968 meeting. You will find the proposal attached to this letter. Members of the committee will be pleased to discuss this proposal with departmental faculties upon request.

Subsequent to the formation of the original committee, the ASEE Committee on "Goals of Engineering Education" issued a report strongly urging Schools of Engineering to expand their offerings for post-baccalaureate education. This extensive report may have a strong influence on the future education of engineers. It is given in full in the January 1968 issue of the Journal of Engineering Education.

At the Spring 1967 meeting of the College of Engineering the report of the ad hoc committee was endorsed in principle and the details were to have been presented again in the fall quarter and voted upon at that time. The committee was unable to get concrete proposals from interested departments in time to meet that deadline and issued a negative and somewhat pessimistic memorandum on February 15, 1968. Shortly after this there were further expressions of interest accompanied by concrete proposals. The committee then agreed that it as a committee and its members as individuals could support the attached program with enthusiasm.

The recent Goals of Engineering Education report says that over 50% of the engineers holding Master's degrees in 1964 practiced in a design and development capacity. The Goals report concludes from this that there is a need for Master's programs to support the needs of the applications-oriented engineer as well as those of the teacher and scientist. This proposal is founded on the conviction that each of these professional functions is equally challenging and, therefore, each deserves supporting programs of equivalent value but of different character. It also recognizes that the ability of a student to pursue a quality program in the disciplines of synthesis and design may not be clearly established by his undergraduate Grade Point Average and that other performance criteria should also be considered to open the portals to further study in design-affiliated disciplines. The Goals report suggests that there is room for a post-baccalaureate program closely linked to the student's undergraduate study which is structured to accent the application of that body of knowledge rather than to pursue new and advanced levels of inquiry. Concurring with that recommendation, this program is identified as an extension of his undergraduate education.

The continuing discussion has resulted in a number of desiderata, some of which are formally included in the proposal and some of which are offered for the guidance of the governing committee and the administering departments.

1. This program should in no way be compared with the current M.S. program of graduate work. Some students may be equally eligible for both programs and should base their choice upon their ultimate objectives--professional design on the one hand and teaching and research on the other. Some students may be eligible for one or the other program but not both; in this case there can be no conflict.

2. The cornerstone of the program is the Design Project. It must be substantial, educational, and of a high professional level. It must be carried out by the student as an

individual effort with no professional assistance other than the guidance provided by his committee and in particular by his project supervisor. Subprofessional assistance, properly acknowledged, may be permitted. While there is no essential objection to a design project associated with the student's employment, it must be clearly understood that exceptions to the requirements of individual responsibility, faculty supervision, and advance faculty approval cannot be permitted; no classified or "company confidential" material may be used.

3. While close liaison should be maintained with the Graduate School, the responsibility for the success of the program lies with the Institute of Technology. Because of the specialized nature of the program, its supervision must rest with those most intimately related to its objectives. In this way, any confusion between this program and graduate study leading to an M.S. with emphasis on research should be reduced.

4. Because of the difference in objectives, financial assistance in the form of traditional traineeships and fellowships would not be available for the Master of Engineering program. In some special cases these students might be particularly qualified to assist with undergraduate design and laboratory courses as teaching assistants or associates. It is hoped that, in addition, new financial support programs--principally from industry--will develop to assist these students.

5. New criteria of admission must be developed to reflect the new requirements stated. For this reason, the objective criteria have deliberately been left for the administering committee to develop.

6. Faculty support for this program should not be had at the expense of current graduate study offerings. While some departments can now offer this program on a modest and experimental basis with no increase in faculty burden, it is clear that any substantial program must eventually be reflected in the available budget.

7. Finally, it is recommended that the program be adopted for a period of five years after its inception. At the end of the five-year period, a review should be initiated with a decision to be made concerning continuance of the program. If it appears desirable to make changes in the program before the expiration of the five-year period, individuals or departments proposing such changes should make recommendation to the Joint I.T.-Graduate School Professional Masters Committee. Any changes thus thought desirable by this committee should be brought before the I.T. faculty for action.

November, 1968

C.E. Bowers
W. Ibele
H. Isbin
R. Lambert
R. Plunkett
R. Swalin (Chairman)

PROPOSAL
(Revised)

The faculty of the Institute of Technology hereby institutes a nominal one-year program of design-oriented study beyond the B.S. degree subject to the following regulations:

Recent studies of engineering education have concluded that a year of further study beyond the customary four-year baccalaureate is often desirable to prepare engineers for future work in design or management. A prospective student may be neither interested in nor properly prepared to undertake the preparation for research and teaching embodied in the Master of Science programs now offered through the Graduate School. To satisfy this additional demand, the various engineering departments offer a one-year program, with emphasis on design methods, leading to a degree of Master of Engineering in a specific field (M.C.E., M.M.E., M.Ae.E., etc). The program is designed primarily for students who have already received a bachelor's degree in the same engineering field or who have a bachelor's degree in a related field and appropriate professional experience. The total effort for the year will be spent about 40% in a major field of study, about 20% in a minor, and about 40% on a design study of significant professional content. The program will be administered by departmental or other appropriate professional engineering program committees which will be monitored and advised by a Professional Masters Committee appointed by and jointly responsible to the Dean of the Institute of Technology and the Dean of the Graduate School.

The distinction between the objectives of this program and that of the Master of Science is not clear cut since it depends on intent. Design concerns itself with the application of the knowledge and methods of engineering and of the physical and social

sciences for the adaptation of materials and sources of power to the use of mankind. Thus, any study which focuses on the engineering application rather than on the method or material behavior may properly be called a design study. For example, applied mathematicians have developed mathematical methods for optimal structural design; engineers might well use these methods for a design study of different types of structures to determine construction possibility, cost, sensitivity to construction deviations, or other parametric studies. Studies of the economic tradeoffs involved in aesthetic and sociological compromises would be highly appropriate. In some cases a combination of analysis, synthesis and experimentation would be a suitable design project if the primary objective is the operation of the end product and not on the development of the method.

1. ADMISSION

Prospective students should inquire from the individual departments for appropriate forms and other information necessary. The criteria to be considered for admission will be:

a. Interest in and aptitude for design-oriented and creative programs as evidenced by performance in undergraduate laboratory, professional, and design courses.

b. Technical reports or other evidence of performance in industrial design. Reports on undergraduate projects.

c. Performance in undergraduate curricula. Greatest weight will be placed upon upper division and other professionally oriented courses. Unless there is evidence to the contrary, a GPA of 2.50 or better will normally be considered acceptable for admission. In cases that do not fit the above criteria, consideration will be given to recommendations from faculty or practicing engineers.

2. PROGRAM

Each student will select an advisor from among the graduate faculty in the field

of his interest. After consultation with his advisor, he will submit a specific program to the appropriate Professional Engineering Program Committee for approval and the Professional Masters Committee for concurrence. This program will normally be considered by that committee before the end of the first quarter or equivalent. This program must include:

1. About eighteen credits of upper division or graduate level courses which the appropriate department considers as being a coherent program of major concentration. Courses offered by another department may be designated by the major department as being part of the major for an individual program where this is appropriate. Students whose backgrounds require strengthening may be required to complete additional course work.

2. About nine credits of upper division or graduate level study in a coherent minor program which falls into one of the following categories:

a. Broadening the student's understanding of the social impact of engineering decision,

b. Enhancing the student's potential as an executive, or

c. Increasing the student's appreciation of alternative approaches to the problem of synthesis by being in a technical area which could not normally be considered as being closely related to his major field of interest.

3. A design project equivalent to about 18 credits. This project should involve design, analysis, and synthesis and will culminate in a formal written report and an oral presentation to a committee appointed by the Professional Masters Committee. This committee shall have at least three members:

1. The student's advisor

2. Another member of the Graduate faculty

3. A referee with considerable experience in the design process. It may often be desirable that this member of the jury be a practicing engineer skilled in the field of the design project.

4. If the project supervisor is not the advisor, he should also be a member of the committee.

4. There shall be no language requirement for the Master of Engineering degree.

5. A grade point average of 2.8 must be maintained in all course work exclusive of the design project. The performance on the design project must be acceptable to the committee.

6. All requirements for the degree shall be completed within five calendar years of initial registration.

7. Since the objectives of the two programs are completely different, the recipient of the Professional Masters degree must apply in the usual manner to the Graduate School if he subsequently wishes to pursue work toward an M.S. or Ph.D. Where appropriate, the Graduate School may accept course work from the Professional Masters program as appropriate for the Ph.D. program but is under no obligation to do so.

Proposal of Three-Year
Program of Training and
Research in Urban Transporta-
tion.

PROGRESS REPORT

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Proposal of Three-Year Program
of Training and Research in
Urban Transportation.

PROGRESS REPORT

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